PENNSYLVANIA

wants plate
here 2-13

To Wm. Firth Esqr. of Leeds.
with kindest regards,
by the Author.

THE GEOLOGY

OF

PENNSYLVANIA

PULPIT ROCKS, WARRIOR RIDGE, HUNTINGDON C^o

Presented to
William Firth Esqr.
of Leeds.
with ~~the~~ kind regards
by the Author.

THE

GEOLOGY

OF

PENNSYLVANIA

A GOVERNMENT SURVEY

BY

HENRY DARWIN ROGERS

STATE GEOLOGIST

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IN TWO VOLUMES

VOL. I.

MDCCCLVIII

PREFACE.

The Geological Survey of Pennsylvania, the chief results of which are embodied in this Work, was commenced early in the year 1836, in obedience to an Act of the Legislature authorising " A Geological and Mineralogical Survey of the State, &c ;" and the State Geologist was directed "to make annual reports to the Legislature of the progress of the Work ; and cause to be represented on the State Map, by colours and other appropriate means, the various areas occupied by the different geological formations ; and on the completion of the Survey, to prepare for publication a full account of the Geology and Mineralogy of the State."

" By virtue of this Act the Author was appointed to conduct the Survey, which he actively prosecuted with a corps of able assistants for six years, until the appropriations were expended." " At the time of the organisation of the Survey, it was estimated that it would occupy at least ten years ; but the financial embarrassments of the Commonwealth made it expedient to withhold further appropriations after the sixth year, and to bring the Survey abruptly to a close before it could be completed in all its parts. The State Geologist, anxious to make the Work as full and symmetrical as possible, continued the exploration, and devoted himself to the preparation of the general final Report for three years longer, labouring for the chief part of this period without salary, and at his own expense." " The mass of information and material collected by the Survey, and thus systematised and prepared for the press, was deposited in the Office of the Secretary of the Commonwealth early in the year 1847, to await publication by the Legislature." In that position it was allowed to remain until the spring of 1851, when, on the recommendation of a joint Committee of the Senate and House of Representatives, from whose Report the above statements are extracted, funds were appointed and measures taken " for the revision of such portions of the field-work as, from the rapid development of the mining districts of the State, required re-survey, and for the publication of the Report itself, with the accompanying maps, plates, cuts, and sections, in a style suitable to the exigencies of the Work and the reputation of the Commonwealth." In the language of another Committee—a Select Committee of the Senate appointed early in 1855 to inquire into the progress and condition of the Survey, and the steps necessary to complete its publication—"A joint committee, consisting of two members of each branch of the Legislature, with the then Secretary of the Commonwealth, was authorised to issue proposals for a contract under which the publication of the Work might be made." This contract, which embraced a provision for further field-researches, was awarded, ill-advisedly, to wholly incompetent parties, who, on the eve of bankruptcy, dissolved copartnership. The contract was allowed to pass "to their successor, who soon after suspended payment." "The publishing firm which succeeded that with which the Committee originally contracted, was finally dissolved by the death of the senior partner; and *another* firm took its place, which, after a short-lived existence, soon likewise disappeared. No commercial firm then remained, even in *name*, to represent the parties with whom the Commonwealth had contracted. Although the publishers had drawn, on account of their contract, the sum of four thousand dollars over and above the amount paid to the State Geologist (for his field-work, &c.), they do not appear to have made any progress towards the publication of the Work." "The funds so advanced to the publishers, and for which the State has received no equivalent, are totally lost, as no sufficient security was taken to cover these advances."

The Committee of the Senate making this recital, adverting to the want of proper management which resulted in this loss, and the delay in the publication of the Work, proceed to say, that "the State Geologist meanwhile commenced his field-work early in the spring of 1851, and continued, with a small band of assistants, actively engaged in it until the close of the season." "Having consumed his own means in the expectation of immediate reimbursement, he appealed to the Legislature for redress, which he procured." Next year "a large amount of material was ready for the press," and "the Geological Map was placed in the hands of the publishers for engraving;" but, for the causes already recited, no progress was made. Notwithstanding the many impediments in his path, arising mainly from delays in procuring his quota of the funds, the Geologist persevered in his field and closet labours until the spring of 1855, the limit allowed by the Act of 1851.

At that date he presented a memorial to the Legislature, calling attention to the bad management which had retarded the production of the large mass of information collected by the Survey, whereupon the Select Committee of the Senate already mentioned, sketching the advanced condition of the Work under its revised and greatly-expanded form, and presenting a Schedule of its materials, for the most part *re-drawn* and almost entirely *re-written*, recommended "to confide the whole Work, in its supervision and publication, to the State Geologist himself." In accordance with this suggestion, it was so enacted in March 1855: the conditions of the contract between the Commonwealth and the Author being, that for the publication of the final Geological Report of the Survey made by him on behalf of the State, with the accompanying maps, plates, cuts, and engravings, including the enlargement of the Geological Map of the State to twice its scale, and the furnishing to the State of one thousand copies thereof within three years, he was to receive the sum of sixteen thousand dollars and the copyright of the Work. Fourteen thousand dollars of this fund was the amount originally allotted to the publication upon an estimate in 1851, made before the revision was undertaken, and the other two thousand were added for the enlargement of the chief Map.

To save from loss a portion of the large amount of useful information collected, and to meet the expectations of the public, the Author has deemed it his duty to expand his Work, both in the illustrations and the text, considerably beyond the amount of material he proposed to print in the Schedule submitted to the Senate's Committee in 1855. The actual cost of the Work has, therefore, exceeded by several thousand dollars the amount to which he is legally entitled. The enlargement of the General Geological Map of the State—a task of great labour, amounting to a total reconstruction of it, and the introduction of much additional and fresh material—has itself entailed a far larger expenditure than was assigned it. Intended to represent, with close and faithful minuteness of detail, a country of excessive topographical and geological intricacy, it required its geographical features to be executed on copper, in the very best style of map-engraving, and the geological ones to be done by the beautiful modern process of colour-printing from stone. Both it, and the minor maps, and other illustrations executed in this manner, will, the Author trusts, meet the approval of his fellow-citizens and of his readers generally. A statement of these facts has seemed due, first, to the public, who have long looked for the fruits of the Survey; and secondly, to the Author himself, who has encountered, in the performance of his duty, unusual obstacles and hardships.

At the time the Geological Survey was organised, it was not contemplated to construct any new maps for the elucidation of the Geology, but simply to represent, "by colours and other appropriate means, as the law expressed it," the areas occupied by the different geological Formations on the Map of the State, then the property of the Commonwealth. The Survey had not proceeded far before it was discovered that that Map, full of errors, was wholly unsuitable for the purpose, and it became apparent that a correct delineation of the Geology demanded either the construction of a wholly new Geographical Map, or a thorough revision and correction of its most defective parts, embracing the entire Mountain-chain of the State. This voluntary addition to the arduous labours of the Geological portion of the Survey was undertaken and persevered in, until a wholly new Map was formed—compiled in part from original Surveys, in part from the numerous explorations ordered by the State, in connection with her internal improvements—and was presented in 1847 as an accompaniment to the general description of the Geology then handed in for publication. In the preparation of that Map, all the larger features of the Mountain-chain, and of the plains and hills to the south of it, and of the table-lands to the north, were critically examined and laid down with approximate truth, though not with the refined accuracy of a trigonometrical survey, upon a scale of one inch to the mile, upon two preliminary maps; one embracing the region south-west of the Susquehanna, the other the country of the Anthracite Coal-fields between that river and the Delaware.

Upon the revival of the Survey in 1851, reorganised more expressly for a closer study and exhibition of the previously less explored parts of the State, especially the Anthracite Coal-fields, it was discovered that the Map embracing these, though exact enough for the general purpose which it had fulfilled, of improving this part of the State Map, was too inaccurate a topographical foundation for the reception of the very intricate geology of the region to be depicted. It became necessary, therefore, to construct a new Map of the whole Anthracite country; and this proved to be a very laborious and costly part of the Survey. Without any separate appropriation for the object, an independent instrumental Topographical Survey was carried on side by side with the Geological one, and the results of both embodied in a series of local Maps, some of them on a scale nearly as large as four inches to the mile. From these Field Maps the Geological and Topographical Map of the Anthracite Region has been carefully constructed. But for the geographical labours incidental to the Survey, the whole Work might have been in print years ago, and at a materially less cost to the Commonwealth. Had the Geologist been provided, as he usually is in such investigations, with sufficiently truthful and large maps ready engraved to his hand, there would have been not only this important saving of time, toil, and expense, but a corresponding economy in all these particulars in the preparation of the Work for the press, and in the supervision of it while in the hands of the artists. The reader will observe that all the maps which accompany this Work are what are called in the United States "Topographical;" they picture, that is to say, by appropriate shading, the physical relief or inequalities of the surface. In this feature they embody a far larger amount of information, both geological and geographical, than can possibly be conveyed through geological charts destitute of hill-work; indeed, no map can be said to meet the wants, either scientific or practical, of a geological survey, which does not picture, approximately at least, the *vertical* element as well as the horizontal. Every Physical Geographer, every Engineer, indeed every working Miner, will testify to the correctness of this assertion. Partly for this reason, and partly through the necessity for making new and more accurate maps of some sort, whereupon to present the Formations of the State, the Author thought it best, while conducting the two-fold Survey, to knit together the Geology and the Topography as intimately as the means at his disposal would permit.

In the Palæontological portion of this Work two principal objects have been kept in view; first, to exhibit the most characteristic organic remains of the fossiliferous formations of the State; and secondly, to ascertain, describe, and figure all the more prominent new species found in the Carboniferous Rocks, especially in the Coal-formation proper. The fossils of the various deposits have been carefully examined and compared, and due weight has been assigned them in the classification and grouping of the strata; but as a thorough Palæontological exploration did not enter into the plan of the Geological Survey of the State, being precluded by the stintedness of the funds appropriated, the Author has contented himself with introducing only so much of the subject as will fully illustrate the typical nature of the ancient forms of life entombed within the different formations, except in the instance of the extinct vegetation of the Coal. Even had he been allowed the funds to conduct an independent Palæontological investigation, a large portion of the labour might have seemed superfluous, from the circumstance that the neighbouring State of New York, far richer than Pennsylvania in well-preserved organic remains, including, moreover, most of the same species, has for many years past been conducting, at great expense, a thoroughly minute investigation of its Fossils—extending, indeed, to other States—by the ablest Palæontologist of the country, Professor James Hall. I am indebted to my accomplished Assistant, Leo Lesquereux, Esq., for the valuable essay and beautiful figures illustrating the new species of Coal Vegetation, discovered chiefly by himself in the Anthracite Coal-fields of the State.

The intimate relations of the Geology of Pennsylvania to that of the whole Appalachian Basin, or the region between the Atlantic Slope of the Continent and the Central Plains west of the Mississippi, and the importance of co-ordinating its strata, especially its Coal-rocks, with those of other districts, the better to illustrate its true position industrially as well as physically, have induced me to introduce a somewhat full Essay on the General Geology of the United States. It is intended to fulfil the office of a key to the more minute descriptions contained in the main body of the Work—to be to the Geology of the State what a general map on a small scale is to a local one greatly amplified; or what a "Finder Telescope," embracing a wide field of view, is to the chief instrument directed upon a special star, the general *place* of which the other shows.

A like motive—a desire to indicate the positions occupied by the several widely-diffused Formations of Pennsylvania and the United States in the general scale of the strata best known to the geological world (I mean the scale of the European Rocks)—has impelled me to add an Essay, originally presented in abstract to the British Association, "On the Correlation of the American and British Palæozoic Strata." It is only through such wide comparisons, cautiously instituted, that we can learn with what portions of the world our country is in nearest affinity.

In the Appendix to this Work there appears, amid other miscellaneous matter, a description of the methods of research employed in the Geological Survey of Pennsylvania, with some suggestions in relation to geological explorations generally, adapted to other countries.

The nomenclature of the Palæozoic Formations employed in this Work demands a word of explanation here. After a mature analysis of the whole system of Ancient Secondary (Palæozoic) Rocks embraced in the Appalachian Chain, conducted in accordance with their organic remains and mineral composition, it became apparent to the State Geologists of Virginia and Pennsylvania, Professor W. B. Rogers and myself, that none of the existing systems of nomenclature—neither the imported British ones, nor the narrowly local geographical ones of New York—were applicable to our strata, under the average types they manifest in the mountain-chain and the broad basin of the States to the West of it. It was found that these Appalachian Rocks were far from being sufficiently co-ordinate with the European Palæozoic strata, under their British types, to bear their names; while, on the other hand, the special titles assigned to them in New York were deemed too local and too inexpressive, either of their position in the scale of Formations, or of their ruling characters, to be usefully applicable.

The fifteen Formations, or series of deposits, defined by their prevalent organic remains, and of the physical horizons which separate them as sediments, extending from the lowest deposited in the dawn of animal life to those formed at the end of the Coal Period, are called by names significant of their relative ages, the words employed suggesting metaphorically the different natural periods of the day. These names are—Primal, Auroral, Matinal, Levant, Surgent, Scalent, Pre-meridian, Meridian, Post-meridian, Cadent, Vergent, Ponent, Vespertine, Umbral, and Seral, meaning respectively the Formations of the Dawn, Daybreak, Morning, Sunrise, Mounting Day, Climbing Day, Forenoon, Noon, Afternoon, Declining Day, Descending Day, Sunset, Evening, Dusk, and Nightfall. Some such nomenclature, based on time, is, for many reasons, preferable to the inexpressive ones which rest for the most part on geographical terms, only locally correct, or on narrow and inconstant palæontological characters.

I avail myself of this opportunity to express my ever-grateful and affectionate acknowledgments to my brother, Professor William B. Rogers, for the valuable assistance he has generously rendered the Survey in every department at various stages of its progress.

The staff of Assistants on the Survey of the State necessarily fluctuated with the vicissitude of its history, and the changing demands of the work. Small at the commencement, it was rapidly augmented to a corps of twelve, which it remained till towards the suspension of the appropriation in 1842; after which, until 1845, whatsoever aid I required was chiefly employed on my own account. Upon the resumption of the field-work in 1851, a new staff was organised, consisting of two Geological Assistants, a Topographer, Assistant Topographer, and a party of Surveyors.

In the campaign of 1836 the assistants were John F. Frazer (now Professor Frazer), and James C. Booth (since Professor Booth). In that of 1837 they were Messrs Samuel S. Halderman, Alexander M'Kinley, Charles B. Trego, and James D. Whelpley, Geologists; and Dr Robert E. Rogers, Chemist.

In that of 1838 they were Messrs Harvey B. Holl, Alexander M'Kinley, Charles B. Trego, James D. Whelpley, James T. Hodge, Dr Robert M. Jackson, John C. M'Kinney, Peter W. Shaeffer, and Townsend Ward, Geologists; and Dr Robert E. Rogers, and Martin H. Boye, Chemists.

In that of 1839 the corps was nearly the same, Mr Peter Lesley and Dr Henderson being added, and Messrs Whelpley and M'Kinney resigning.

In 1840 the corps consisted of the same assistants, with the addition of an able Draftsman, George Lehman.

In 1841 the number of the Geological Staff was reduced, the Geologists being Mr M[c]Kinley, Mr Holl, Dr Jackson, Mr Lesley, and Mr Boye; and the Chemist, Dr Rogers.

After the revival of the field-work in 1851, the Geological Assistants were Professor E. Desor and William B. Rogers, junior. The Topographers were Peter Lesley, and subsequently Augustus A. Dalson; and the chief Surveyors, Peter W. Shaeffer (performing also geological functions) and Henry W. Poole. The neat one-sheet Map of the Coal-fields is by Mr Lesley. The beautiful large Map of the Anthracite Region is by Mr Dalson, chiefly from his own surveys.

Since the cessation, in the autumn of 1854, of the active revision of the Mining Districts, and of the Topographical Surveys, my sole assistant in geological field-research, in completing unfinished topographical work, and in preparing for the press the final Drawings of the extensive mass of Geological Sections and Diagrams introduced into this book, has been my nephew, William B. Rogers, junior.

Besides the gentlemen here mentioned as scientific assistants, the Survey has employed many other persons, some of them of much skill and merit, in subordinate capacities. One of these, Patrick Daly, merits especial mention for the value of his services and fidelity to the Survey.

For full mention of the special parts performed by the individual members of the corps in the various successive stages of the Survey, I beg to refer to the widely-circulated Annual Reports of its progress. To attempt a precise history of the labours of each, in a field where their duties were so multifarious, would, besides being somewhat invidious, lead me into too minute and tedious a narrative.

I beg, in concluding this Preface, to testify in general terms my high appreciation of the zeal and ability of my Assistants, my admiration of their energy in confronting difficulties, and their fortitude in meeting the privations and hardships incident to the life of a Geologist in the United States; and my grateful thanks for the personal devotion displayed by all of them, with one or two exceptions, in aiding me to the fulfilment of my duties.

HENRY D. ROGERS.

PHILADELPHIA, *April* 1858.

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(*PRINTED IN THE TEXT*).

ERRATA.

Page 174, line 32, for Fig. 25, read 23 *a*, *page* 181.
„ 216, line 15, for *Marble Hill*, read *Marble Hall*.
„ 383, line 21, for *Pre-Meridian Sandstone*, read *Meridian Sandstone*.
„ 476, line 1, for *Baird's*, read *Betty's*.
„ 505, last line, for *Williamsport*, read *Williamsburg*.
„ 543, line 11, for *Levant formations*, read *Surgent formations*.
„ 554, line 19, for *Levant ore calcareous shales*, read *Surgent, &c.*
„ 554, line 22, for *Surgent shales and marls*, read *Scalent, &c.*
„ 559, line 34, for *Black Knob*, read *Blue Knob*.

GEOLOGY OF PENNSYLVANIA.

INTRODUCTION.

PHYSICAL GEOGRAPHY OF PENNSYLVANIA.

A TRUE notion of the Geology of a region so complex as Pennsylvania cannot be easily acquired without a preliminary survey of its Physical Geography. The external relief, or surface-modelling of a country, is indeed but the expression of its internal rocky structure, as moulded by the erosive action of moving water and the slow chemical influences of the atmosphere. The contour of the ground is the sculpture which guides to the anatomy within; and it is as needful to note the slopes, projections, and wavy outlines of the surface, while studying the mineral masses beneath it, as it is for the anatomist to employ the perceptions of the artist.

Few districts of the globe—certainly no portions of the wide Appalachian area—disclose this connection between the external physical features of the land and the characters and positions of the strata, more plainly than the State of Pennsylvania. I shall therefore preface my account of its Geology by a sketch of its external features. While describing these, it will be expedient to offer a brief sketch of the hydrography or river-drainage of the region, and to introduce some general statements respecting its climate, especially the conditions of temperature and rain, which control so entirely the irrigation of the surface. But first of all it is essential that I define the Boundaries and Position of the State.

BOUNDARIES AND AREA.

Pennsylvania is bounded on the N. by the east and west line which separates it from New York and by Lake Erie; on the E. by the Delaware River, dividing it from New York and New Jersey; on the S. by the States of Delaware, Maryland, and Virginia; and on the W. by a part of Virginia and Ohio. The length of the State in an E. and W. direction is about 310 miles, and its breadth 160 miles. Its shape is nearly that of a parallelogram. It lies between latitudes 39° 42′ and 42° 15′ N., and between the meridians 2° 18′ E., and 3° 32′ W. from Washington. The surface of the State embraces very nearly 44,400 square miles, or 28,416,000 acres. The central and northern parts are mountainous, but include many ample valleys of great fertility and beauty, while the south-eastern and western portions possess a more gently undulating surface. The height above the sea of the loftiest ridges and table-lands scarcely exceeds 2800 feet, and the average elevation of the whole surface is probably about 600 feet.

POSITION OF THE STATE.

The position of this State in relation to the great slopes, and therefore to the river systems of the country, is most interesting and important. An inspection of the geological map will show that, while the territory of the Commonwealth touches the Atlantic tide-water plain at its south-eastern border, and derives therefrom the invaluable privilege of a free outlet to the ocean, it embraces the Atlantic Slope, the whole breadth of the Appalachian Mountain-chain, and nearly all the upper or north-eastern extremity of the great and fertile basin of the Ohio River. It has the further advantage of touching upon the great basin of the Lawrentian Lakes, destined soon to be one of the grandest commercial avenues upon the continent. This it does at the sources of the Genesee River, in Potter County, and in Erie County, near the lake of that name. Thus it shares with New York the rare privilege, possessed by no other State of the confederacy, of holding the head-waters of the three great river-systems of the eastern half of the continent, a drainage to the Atlantic, to the Gulf of Mexico, and to the Gulf of St Lawrence. In physical position, therefore, as in other respects, these two noble territories, placed at the focal water-shed of this widely-diverging drainage, may justly be regarded in the light of a double keystone to the great dome of the Union.

GENERAL WATER-SHED AND MAIN SLOPES.

It will assist us to a clearer understanding of the special features of the several divisions of the State, if we first examine its primary water-shed, and the chief slopes which depend from this. The great axis of river-drainage, of which it forms a part, after separating the Atlantic streams from those which flow into the lakes and into the Ohio River, and pursuing a very meandering course from near Lake Champlain, south-west across New York to the sources of the Genesee River, and the N. and W. branches of the Susquehanna, enters Pennsylvania in Potter County, between the head-streams of the Genesee and those of the Tioga. Here the ground has an elevation of from 1650 to 1700 feet. The line of water-shed, in crossing the State, observes a general S.W. course, winding through the counties of Potter, McKean, Elk, and Clearfield, into that of Indiana, dividing Pine Creek from the Genesee River, and then separating the head-streams of the Sinnemahoning, first from those of the Alleghany, and then from those of the Clarion, and, further south, the sources of the West Branch from those of the Red Bank and Mahoning. In Indiana County the line alters its direction, and runs S.E. through Cambria to the crest or south ridge of the Alleghany Mountain, dividing the upper waters of the West Branch of Susquehanna from those of Conemaugh. Turning again at the Alleghany Mountain, a few miles west of Hollidaysburg, the water-shed pursues the summit of that ridge, or rather table-land, the whole distance to the south-eastern corner of Somerset County. There it deflects gently S. round the western springs of Wills' Creek, which it divides from the eastern feeders of Castleman's River, and reaches the crest of the Savage Mountain about the southern boundary of the State. This summit-line between the eastern and western waters observes a gentle undulation in its level above the sea. First slowly rising from its mean elevation of 1650 feet in Potter County, it reaches about 1900 feet in M^cKean, at the sources of the Driftwood branch of Sinnemahoning, and thence it very gradually declines all the way to Indiana County, where, near the extremity of Chestnut Ridge, it is about 1200 feet; thence it ascends, first gradually and then rapidly, to the Alleghany Mountain, upon the summit of which, between the waters of the Juniata and the Conemaugh, it has an elevation of 2790 feet. From this its maximum level, the crest of the mountain, with which it coincides, very gently declines to an elevation of about 2550 feet at the sources of Wills' Creek, and with nearly this elevation the water-shed passes southward into Maryland.

From the above traced backbone of the land—if an axis of drainage so little prominent above the rest of the surface can be so styled—the general level declines both ways; E. towards the Atlantic, and W. towards the immediate valley of the Alleghany or Ohio River. The south-eastern slope, which is by far the longest, though a nearly continuous inclined plane, when we regard the floor upon which the drainage descends towards the sea, has a curved or almost arched form when we view it in profile, and trace it through the summits of the table-lands and ridges of the Appalachian Chain. In other words, the main crest of the Alleghany Mountain, though it springs from a lower base than the primary water-shed, is higher than the sources of the streams.

The district west of the primary water-shed is not a simple slope even at the level of its streams, but is a great irregular trough, the terminal portion of the basin of the Ohio River, undulated in its south-eastern corner by the ridges called Negro Mountain, Laurel Hill, and Chestnut Ridge, and bounded N.W. by a flat water-shed dividing it from a series of short streams that descend to Lake Erie. The north-western boundary of the western basin, or the water-shed separating the streams of French Creek and Chenango from those of the Ashtabula, Conneaut, Elk Creek, and other tributaries of Lake Erie, has a mean height in Erie County of about 1200 feet.

Thus, dividing the State hydrographically, we find it to include three natural areas—1st, A great eastern slope, descending from the primary water-shed to the tide-water plain of the Atlantic sea-board; 2d, A great irregular trough, descending S.W. from the northern boundary of the State on the confines of Potter, M^cKean, and Warren counties, and watered by the feeders of the Ohio River; and, 3d, A narrow slope in Erie County, declining to the lake.

Orographically regarded, or classified in accordance with its external features, or the contour of its upland surface, and not by the planes of its drainage, the State admits of a somewhat different subdivision. So viewed, it embraces five naturally distinct regions.

The *First* is that of the Atlantic Slope, a district in the S.E. angle of the State, embraced between the tidal waters of the Delaware and Susquehanna, and the S.E. base of the first main range of hills, the South Mountains.

The *Second* comprises the whole Appalachian Chain, restricting the definition of this to all the ridges and table-lands included between the S.E. base of the South Mountains and the summit of the so-called Alleghany Mountain.

The *Third* comprehends all the country N. and N.W. of the Alleghany Mountain, except the two districts north of the northern table-lands of the bituminous coal-fields—namely, that in the N.E. part of the State occupied by Susquehanna, Bradford, and a portion of Tioga counties, and that in the N.W. by Erie, Crawford, and the northern half of Warren.

The *Fourth* is the just named district in the N.E., watered by tributaries of the North Branch of the Susquehanna. Though drained by an Atlantic river, it belongs orographically to the valley of the St Lawrence, being the first or highest of the succession of plains or terraces by which the surface descends to Lake Ontario.

The *Fifth* is the already mentioned district lying outside and N.W. of the plateau fringing the bituminous coal-field in Warren and Crawford counties. In the slope of its surface, though not in all its drainage, it belongs to the basin of Lake Erie.

OROGRAPHY AND SCENERY OF THE FIRST DISTRICT.

The first district, or the portion of the *Atlantic Slope* embraced within the State, is a beautifully diversified, undulating, fertile plain, rising from a few feet above the level of the sea to the base of the South Mountain, where, at the Delaware River, it has an elevation of about 150 feet, at the Schuylkill of about 175, and at the Susquehanna of about 300 feet. While it thus gradually rises northward, it observes a still more gentle ascent south-westward, or in the longitudinal direction of the great zone, of which it forms a part, and which, starting from the tide-level of the Hudson, slowly ascends to a height of more than 1000 feet at the sources of the Roanoke in North Carolina. That the Pennsylvanian portion of the Belt steadily increases in altitude the whole way from the Delaware to Maryland, is plainly visible, so soon as we compare together the elevations above cited, at which its upper margin is intersected by its great rivers, the Delaware, Schuylkill, and Susquehanna.

A more than usually diversified geological constitution confers upon this tract much variety of pleasing scenery. Above the level of its comparatively smooth general surface rise numerous hills and low ridges of swelling outline, and within the plain are some exceedingly lovely and richly cultivated valleys. A prevailing softness of contour distinguishes its lower portion especially. This is attributable to a general absence of the harder igneous rocks and coarse sandstones, and to the presence of the easily rotted and crumbled varieties of gneiss, semi-metamorphic schists and limestones which underlie the surface. The northern half of the plain, composed for the most part of a broad zone of friable red shale and argillaceous sandstone, exhibits even smoother lines of landscape, except where dykes and ridges of a greenstone trap-rock, protruding themselves through the softer mass, constitute almost the only rough ground and abrupt slopes to be found in the whole district. The entire plain was originally heavily wooded; and many of its eminences, especially the more stony hills and steeper river-banks, still remain so, though in very few instances with any remnants of the primeval forest. Its larger rivers flow for the most part between high banks; those of the lower Susquehanna are by far the boldest, ascending abruptly from 100 to even 200 feet above the water.

This favoured district of the State, blessed with a temperate and salubrious climate, with a fertile soil, and a large share of mineral wealth beneath it, is at the same time admirably irrigated. It is traversed by the lower sections of the three noble rivers, the Delaware, the Schuyl-

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GNEISS ROCKS, NEAR MOUTH OF THE WISSAHICKON kill, and the Susquehanna, and by many beautiful lesser streams their tributaries, some of which are themselves true rivers in the capaciousness of their drainage. Abundantly and steadily watered by light rains and frequent showers throughout all periods of the year, saving occasionally a few weeks of drought in summer, and with a total annual rain-fall of nearly 40 inches, few parts of it, however limited, are destitute of fertilising running brooks. Altogether it, and the corresponding tracts in New Jersey and Maryland, may be esteemed the garden of the Atlantic Slope.

Scenery.—A fair conception of the river-scenery of this district may be derived from the pictorial section of the Schuylkill between Philadelphia and Norristown, that of the Susquehanna at Columbia, and that between Wrightsville and Havre-de-Grace, as likewise from the sketch of the Wissahickon near its mouth. One of the most picturesque ranges of river-cliffs within this region is the bold escarpment of red sandstone in Bucks County on the Delaware, called the Nockamixon Rocks. The larger rivers have a scenery peculiarly their own; they are broad and very shallow, and, except when swollen with freshets, disclose the outcropping edges of the harder strata across which they flow, and which cause long reaches of rapids that impart a lively effect to the landscape. All of these streams, the Susquehanna more particularly, are studded with small islands and low bunches of rocks, richly clothed with trees and shrubs, drooping their branches into the swiftly-passing current. These constitute one of the most attractive and characteristic features of the river-scenery of the district. The accompanying sketch of a scene on the Schuylkill, including the upper part of the manufacturing town of Manayunk, will convey some notion of the aspect of the smaller shallow river-channels, where the outcrops of the strata are naked.

OROGRAPHY AND SCENERY OF THE SECOND DISTRICT.

The second district, or that part of the *Appalachian Chain* which traverses the State, is a mountain-zone of very uniform general aspect, though internally and locally of much diversity of structure and scenery. It is remarkable for the extraordinary length, slenderness, steepness, evenness of summit and parallelism of its multitudinous crests or ridges. It is constituted of five well-marked parallel belts, stretching from N.E. to S.W., which, viewed in geographical order north-westwardly, are—1st, the South Mountains, Highlands, or Blue Ridge; 2d, the Appalachian Valley; 3d, the Central Appalachian Ridges; 4th, the Sub-Alleghany Valley; 5th, the Alleghany Mountain, or S.E. escarpment of the Alleghany Plateau.

The South Mountains, or *First Belt*, is the name given to two entirely detached ranges of hills, the one extending from the Delaware River, below the mouth of the Lehigh, to the Schuylkill River at Reading; the other, from Maryland to a terminating point on the confines of Cumberland and York counties, 10 miles S.W. of the Susquehanna. The first of these ranges, a prolongation of the Highlands of New Jersey and New York, and of the Green Mountains of Vermont, is a belt of compactly set, short, wood-covered ridges and hills, the whole from 5 to 10 miles broad, embracing some pleasing agricultural valleys. Their average elevation above the plain S. and N. of them scarcely exceeds 600 feet; but being abrupt and stony, and presenting a marked barrier to the view, they receive the name of mountains, fitly enough applicable to other parts of the chain, of which they are but the termination. The other range is in like manner the north-eastern termination of the Blue Ridge of the Southern States, a comparatively lofty and broad mountain-belt of singular continuity and great persistency of feature. It also has a very moderate elevation within the State of Pennsylvania, none of the summits rising to a higher level than 600 or 700 feet. There is nothing remarkable in the topographical structure or scenery of either of these divisions of the first belt of the Appalachian Zone. It is only where the Blue Ridge is notched to its base, at the Potomac River, that we meet with an approach to grandeur and pictorial beauty. There the mountains springing abruptly from a low base, and exposing some grand ribs and ledges of fissured and shattered rock, and the swift river obstructed by jagged reefs and islands, form together a scene which contrasts strikingly with the prevailing tameness of other parts of the same range in Maryland and Pennsylvania.

The Appalachian Valley, or *Second Belt* of the chain, bounded south by the South Mountains, and north by the Kittatinny Range, and styled in Pennsylvania the Cumberland or Kittatinny Valley, has the character of a long, nearly straight, and moderately undulating plain. Its breadth varies from about 10 to 18 miles, and it stretches entirely across the State from the Delaware River to the Maryland line. In this distance the valley rises from an average level of 200 feet on the borders of New Jersey, to one of more than 600 feet, where it passes into Maryland. Its height is about 250 feet at the Schuylkill, and nearly 350 feet bordering the Susquehanna. At Carlisle the level is 500 feet, and at Chambersburg 600 feet. The lowest level within the valley in Pennsylvania is at Easton, at the mouth of the Lehigh, where the height above the sea is no more than 165 feet. Its gradual ascent S.W. conforms to the general rise of the entire Appalachian Valley, from the Hudson, where it is washed by the tide, to the interior of the State of Virginia, where its height considerably exceeds 2000 feet; and it is in accordance, indeed, with the general gradual lifting of the entire mountain-chain in the same direction. The longitudinal outline of the valley is somewhat undulating, due to gentle bendings and to abrupt offsets in the mountain-ridges which confine it. From the same causes it assumes several rather sudden contractions and expansions. Thus a few miles eastward of the Schuylkill, a change southward in the crest line of the Kittatinny Mountain shifts the north boundary of the valley some four miles to the south, contracting the width from 17 to 11 miles; but a little west of this, the plain suddenly widens by the falling off of the South Mountain in a series of fingers, until at the Schuylkill its breadth amounts to nearly 18 miles. West of the Schuylkill it contracts again to less than 13 miles at Womelsdorf by the intrusion of an outlier of the South Mountain called "Millbaugh Hill." Near Lebanon it is some 15 miles broad. It again soon contracts to 10 or 11 miles, and retains with slight variation this average breadth to Franklin County, the chief irregularity in size and direction occurring in Cumberland County, where the Kittatinny Mountain falls back by two offsets to the N.W., deflecting at the same time more southward. From Chambersburg to Maryland the plain grows rapidly broader by the successive subsidence of finger-like spurs of the South Mountain or Blue Ridge, and by the termination of the Kittatinny Mountain at Parnell's Knob. At the southern line of the State its width measures nearly 20 miles. Though in certain tracts the surface of this fertile and beautiful plain, especially near the northern boundary of Lehigh, Berks, and Lebanon counties, is somewhat broken and hilly, it is nowhere interrupted as it is in Virginia, Tennessee, and New York, by rugged and lofty ridges. Only a very small portion, indeed, is too rough and stony for the plough, and being by nature admirably watered with abundant rains, feeding innumerable streams and brooks, it is one of the most productive districts of the State. It is as fortunate, too, in its adaptation for manufacturing industry as for agriculture; for besides possessing through its streams, some of which are rivers in their magnitude, an enormous water-power, it has vast treasures of the finest Hematitic iron ore; has more than half its soil underlaid by limestone, and through half its length is in close proximity to unfailing supplies of fuel from the Anthracite Mines of the First Coal-basin. Seated between the Coal-Fields on the one hand, and the Tide-Water Markets on the other, and enjoying a climate and soil favourable to the highest agricultural productiveness, this valley and the Atlantic Slope below it, have, within the last twenty years, since the development of the mines, experienced a progress in wealth surpassed by few other portions of the land.

The *Scenery* of the Kittatinny Valley, though not impressive or specially picturesque, is generally pleasing, and in some localities, where favourable views are procured of the receding spurs of the South Mountains, or of the terminal knobs and river-passes of the Kittatinny Mountain, it is bold and fine. More usually, however, the general evenness of the plain, and the extraordinary levelness, straightness, and regularity of summit of the Kittatinny or Blue Mountain, impart a tameness and monotony to the landscape.

One of the best general views of the Kittatinny Valley in its breadth, with the Kittatinny Mountain in the background, is procurable from an outstanding spur of the South Mountains in New Jersey, called "*Jenny Jump*," nearly opposite the Delaware Water-gap, and distant from it about 12 miles. The broad plain of the valley fills all the middle distance of the landscape, while the straight and singularly level crest of the mountain is spread before the observer throughout an enormous length. To the left of the Water-gap he sees a half notch in the smooth crest called the "*Wind-gap*," and further west, the river pass or water-gap of the Lehigh, distant more than 30 miles. The rolling surface of the valley is pleasingly diversified by farms and patches of woodland; and on the right of the picture, in full view from the observer's station, is the picturesque little village of Hope, formerly a Moravian settlement.

Another, and even more attractive, view of the valley is obtained from any open position on the point or summit of the Neversink Mountain, south of Reading. Here the valley is very broad, and the Kittatinny Ridge far in the distance. Seen from a high point, and through a clear atmosphere, it is like a straight blue wall, notched at the pass of the Schuylkill. It is called the "*Blue Mountain*," evidently from the circumstance that the earliest generation of settlers seldom beheld it nearer than at this blue distance; the whole plain between being for a period an almost pathless forest. At the present day the valley is a well cleared, highly cultivated district. Its northern side is somewhat hilly and broken, embracing a chain of rather barren ridges of slate, but its middle and southern belts are smooth, fertile, and well tilled. The special landscape here referred to includes several beautiful reaches and bendings of the gently-flowing Schuylkill, spanned by bridges, and traversed by a broad low waterfall, caused by a dam diverting the water into a canal which skirts the edge of the river. It is a picture full of attractive objects, beautiful long slopes, and waving lines imparting a certain breadth which characterises all the softer parts of this great valley.

The *Third* or broad central *Belt* of the chain, or that of the Appalachian ridges proper, may be described as a complex chain of long, narrow, very level mountain-ridges, separated by long narrow parallel valleys. These ridges sometimes end abruptly in swelling knobs; sometimes taper off into the valleys, in long slender points. Their slopes are singularly uniform, being in many cases unvaried by ravine or gully for many miles; in other instances trenched at equal intervals with great regularity. Their crests are for the most part sharp, and they preserve an extraordinary levelness, only here and there interrupted by indentations or notches, some of which descend to the valley levels, and give passage to the streams and rivers of the country. The whole chain being the combined result of an elevation of the strata or earth's crust in long, slender, parallel waves, and of excessive erosion of these waves by water, the ridges, which are but the remnants of the wasted strata, are variously arranged in groups with long and narrow crests, some of which preserve a remarkable straightness for great distances, while others bend with a prolonged and regular sweep. In many instances two narrow, contiguous, parallel mountain-crests unite at their extremities, and enclose a deep, narrow, oval valley, which with its sharp mountain-sides bears not unfrequently a marked resemblance to a long, sharply-pointed, slender canoe or skiff. There are two classes of these boat-shaped valleys; one possessing a synclinal structure, or with the higher strata in the middle of the trough, and the lower harder rocks forming the steep, narrow, enclosing mountains; the other having the anticlinal form, being valleys scooped longitudinally out of the summits of the great original crust-waves, by an excessively energetic erosive force of waters cutting through the harder upper strata into softer lower ones. Both classes, though thus begirt by steep, sharp, and very strong ridges, are usually easily entered by more than one notch or gap, affording passways to the streams. These gorges constitute a most important feature in the hydrography of this mountain-belt, as they permit a ready transit at the general water-level of the country, through and among crowded and steep mountain-ridges, which, wherever they are absent, are found to be difficult of passage, even for common roads. It is through them that all the main Atlantic rivers of Pennsylvania wind their unobstructed way to their tidal estuaries, for it is a feature in the drainage of this whole slope of the State, that its chief streams have their sources, either behind the mountains or near their further border, descending across the entire breadth of the chain. Interspersed among the narrower ridges and valleys are here and there wide tracts of mountain table-land of the general height of the narrow-crested ridges: some of these are formed by the merging together of two or more ridges, which usually flatten out before they coalesce; others are broad synclinal plateaus, or high, flat, mountain-basins, subdivided at their ends into a series of spurs, projecting forwards as the human fingers do from the hand; a structure which has resulted from the presence of undulations in the strata, and the erosion or removal of their exposed or anticlinal portions.

Instances.—As an interesting example of the class of long, narrow, very level ridges, we may cite the Kittatinny Mountain or first range north of the Appalachian Valley. Commencing near the Hudson, close to the village of Roudout, it stretches away to the S.W., crossing part of New York, New Jersey, and all Pennsylvania to Franklin County on the border of Maryland, a length approximately of 240 miles. Throughout this course it is a continuous mountain-ridge, which nowhere subsides, but only here and there shifts its crest-line, by a jog or offset, and has no interruption but at the five river-passes, or water-gaps, by which the rivers Delaware, Lehigh, Schuylkill, Swatara, and Susquehanna flow through it. It is therefore well entitled to its name, which, in the language of the Delaware Indians, means the Endless Mountain.

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KITTATINNY M^t FROM LEHIGH SUMMIT MINES.

Many other instances of very long, slender, regular ridges might be adduced, as the Mahoning or Second Mountain, north of the Kittatinny; the Tuscarora Mountain in Juniata County; Jack's Mountain, in Mifflin; Bald Eagle Mountain, running from Lycoming, through Clinton and Centre into Blair and Tussey Mountain, in Blair and Bedford; but nearly all of these are members of groups of ridges, to be described in detail hereafter.

Annexed is a Sketch showing the Kittatinny Mountain in the distance, and the Mahoning or Second Mountain in the middle space. The foreground is the stony crest of the Sharp Mountain, near the Lehigh Summit Mines. This picture will convey a good conception of the features of our monoclinal ridges, with their level crest-lines, their occasional notches, and steep forest-covered slopes.

The instances of long and narrow valleys of anticlinal structure, or where the strata dip away from the central line of the excavated trough, and not towards it, are, as in the cases of a synclinal structure, very numerous. An interesting example is that of Path Valley, in the north-western corner of Franklin County. Another more symmetrical one is Kishicoquillas Valley, in Mifflin. Both these are of simple anticlinal structure at their western ends, but contain several waves of the strata at their eastern, causing them to subdivide into long slender prongs. Kishicoquillas Valley has three such very regular prongs, like a fork, separated by high single-crested synclinal ridges. Penn's Valley is another instance of the same structure, forking eastward. The largest of all is Nittany Valley, enclosed eastward by the table-land which joins Bald Eagle Mountain to Nittany Mountain, and westward by the coalescing of Bald Eagle Mountain with Brush Mountain. Only the lesser anticlinal valleys, such as Nippenose Valley, Sugar Valley, and Black Log Valley, which contain no more than one regular anticlinal flexure, are of strictly symmetrical form. Some of these are extremely slender, being excavations in the backs or crests of long narrow and steep waves of the strata; others, such as Nippenose and Mosquito valleys, are more oval in form, the denuded crust-waves out of which they are scooped being broad and flat.

These anticlinal valleys, even the most slender and regularly terminated, bear much less resemblance to a narrow tapering canoe than do the synclinal troughs, unless we liken them to a narrow boat turned bottom upwards, with the bottom or keel carved out. Instead of their mountain rims or crests ascending towards their ends to unite in a peak, like the prow and stern of a skiff, they run level to near their junction, and the terminal single ridge sinks slowly tapering off, like the cutwater of a slender inverted bark.

The mountain-sides enclosing the anticlinal valleys present quite different contours from those embracing the synclinal. The latter, for the most part, descend with very regular flattening curvature of slope, or if they are terraced, as they frequently are in the anthracite coal-basins, the benches are narrow, and too obscure to form a feature in the landscape, except in rare cases; they are, moreover, seldom gashed by numerous and deep ravines; whereas the slopes of the anticlinal valleys are usually conspicuously terraced and carved by sharp gullies commencing sometimes in the crests of the ridges, but more frequently in the edges of the broad shelves running horizontally round the valleys at different levels on the mountain-flank. Beautiful cases of this terraced structure are to be seen in all the middle and north-western anticlinal valleys of the chain west of the Susquehanna. It occurs conspicuously in Black Log, Kishicoquillas, Penn's and Nittany valleys, and their branches, and also in Morrison's, Friend's, and Millikin's coves, in nearly all of which there is a broad and nearly level bench or terrace high on the slope of the bounding mountains, which from a distance looks singularly like a wide elevated beach formed by pent-up waters. Such, however, was not its origin, as we shall prove hereafter. In those valleys of anticlinal structure, or outward-dipping stratification, such as Nittany Valley and Morrison's Cove, where the inclination of the rocks is very steep, the terrace is proportionately high towards the main crest; and where the dip is nearly or quite perpendicular, and the rocks are equally hard and massive with those in the chief ridge, it becomes a secondary summit as lofty as the primary one, and the mountain is then strictly double-crested, with a long shallow grove or depression between its two sharp ridges.

Wherever these anticlinal valleys subdivide, the mountain-spurs which separate their forks being terraced like the more continuous enclosing ridges, and the terraces or benches being composed of resisting strata, lower in position than those forming the upper main-crests, the latter are obliterated for a greater or less distance short of the terminations of the shelves; and thus high synclinal ridges are seen rising centrally out of the tops of lower, broader ones, which themselves ascend many hundred feet above the level of the valleys below. These mountains, seated upon mountains, are curious and impressive features in the orography and scenery of Kishicoquillas and the other forking anticlinal valleys. A clearer conception of their aspect will be gained by inspecting the geological map, and the picture of Kishicoquillas Valley here presented.

A glance at the map will suffice to show how much more extensively the mountain flanks facing the anticlinal valleys are slopingly trenched and guttered, than those looking into the synclinal troughs.

It will materially assist our conceptions of the topographical features, or external structure of this mountain-zone of the State, if, in this place, we devote a little attention to the several kinds of mountains and valleys of which it is constituted. The elongated, narrow form of the ridges, their general steepness, sharpness, and levelness, have been already adverted to, and mention also has been made of the synclinal and anticlinal valleys, and of the table-lands; but as there are several kinds of ridges, plateaus, and valleys, each class having a distinctive configuration or orographic character dependent on its geological structure, it is expedient that we should define them, and show with what conditions of stratification they are connected.

Mountain Ridges and Valleys.—The ridges or elongated, narrow, continuous tracts of high ground, both those of mountain elevation and the lesser ones, entitled to the name of long, slender hills, are of three orders, resulting from three different forms of the strata composing them. In geological language they are of *anticlinal*, *synclinal*, and *monoclinal* structure. When it is considered that every part of this zone of the Appalachian Chain owes its *relief* to a diffused and powerful cutting or wearing action of waters upon a broad group, or series of groups of great parallel undulations of the strata, or more or less compressed waves in the earth's outer crust, it is apparent that there can exist but three forms of ridges and valleys: 1st, Those consisting of strata bent convexly upward, or dipping anticlinally; 2d, Those consisting of strata bent concavely upward, or dipping synclinally; 3d, Those consisting of strata not recurved in either of these modes, but dipping only in one direction, or monoclinally, and forming the flanks of the waves. These three types of geological structure, shared by the valleys as well as by the ridges, are each of them accompanied by distinctive external forms, or special orographic characteristics, only modified more or less by the relations of the strata in regard to hardness, thickness, angle,

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WEST B^{R} OF SUSQUEHANNA AND BALD EAGLE M^{T} FROM FAIRVIEW INN.

or dip, and other conditions affecting the amount of resistance they presented to the excavating or erosive agency of the waters.

1. *Anticlinal Ridges.*—In their external form, the anticlinal ridges, whether straight or curved, are strictly wave-shaped. Widest and loftiest at the centre, they taper away, contracting and sinking to either extremity, not with a straight, descending crest-line, but with a convex, curving one; indeed, they are most symmetrically and softly arched in longitudinal profile. Their transverse profile is likewise an arch steeper or flatter; but the incurvation, except in the very flattest ones, is seldom symmetrical, one brow and slope of the ridge curving and descending more abruptly than the other. In their lower slopes, and near their base, the curvature flattens off, so that the profile is bell-shaped, though distorted from the unequal steepness above spoken of. In some instances the anticlinal ridge embraces above the level of the valleys around only the upper or crest portion of a wave of the strata; in others it takes in all the convex half of an undulation; and in others, again, it includes, besides this, towards either base, the commencement of the concave dips of the adjoining troughs in the strata outside of it. To speak more generally, it depends entirely upon the relative prominence of the crust-waves, or relative depths to which the waters have pared away the strata from the synclinal troughs, at what level *the neutral plane*, or plane cutting through the straight parts of the flanks of the waves where the convex curves just cease and the concave begin, will be placed in relation to the general valley-level of the country. Upon its position, in an anticlinal ridge, will much depend the style of profile of the mountain, especially towards its base. Of course the foot and lower slope in all cases owes a portion of its flatness to the accumulation of rubbish collected there; but in the Appalachians of Pennsylvania this is a thin mantle, and does not sensibly alter the shapes of the hills even where they pass into the valleys.

The simple anticlinal ridges display upon their flanks and summits various degrees and kinds of erosion from water, dependent upon the nature of the strata denuded. In some cases the crest is grooved longitudinally into a little shallow valley; in others, this grooving extends deeper, reaching soft interior rocks, and then the crest is double, and we behold the first stage of an anticlinal valley enclosed between two monoclinal ridges. Wherever the uppermost hard stratum, lapping over the summit of the mountain, has not been thus longitudinally scooped, the crest is smooth, presenting few notches; but wherever the scooping has formed two narrow monoclinal ridges at the summit, each of these is gashed by many ravines, wide at the top, and contracting as they descend the flank of the ridge.

The picture given of the Lewistown Valley, and Blue and Shade Mountains in the background, illustrates how different the amount of erosion has been on a single-crested and double-crested anticlinal ridge. It displays, furthermore, in the Shade Mountain, the long tapering point, and gently convex descending crest-line, so distinctive of the extremities of the simple anticlinal ridges. Another even more perfect example of this gradual pointing down of these ridges is in the north-east end of the Blue Ridge, as it may be seen from any high spot just above the village of Mifflintown. The Bald Eagle Mountain, as seen from Fair-View Inn, also shows it (see Plate); but the obliquity of the view conceals much of the slenderness of the point of the mountain.

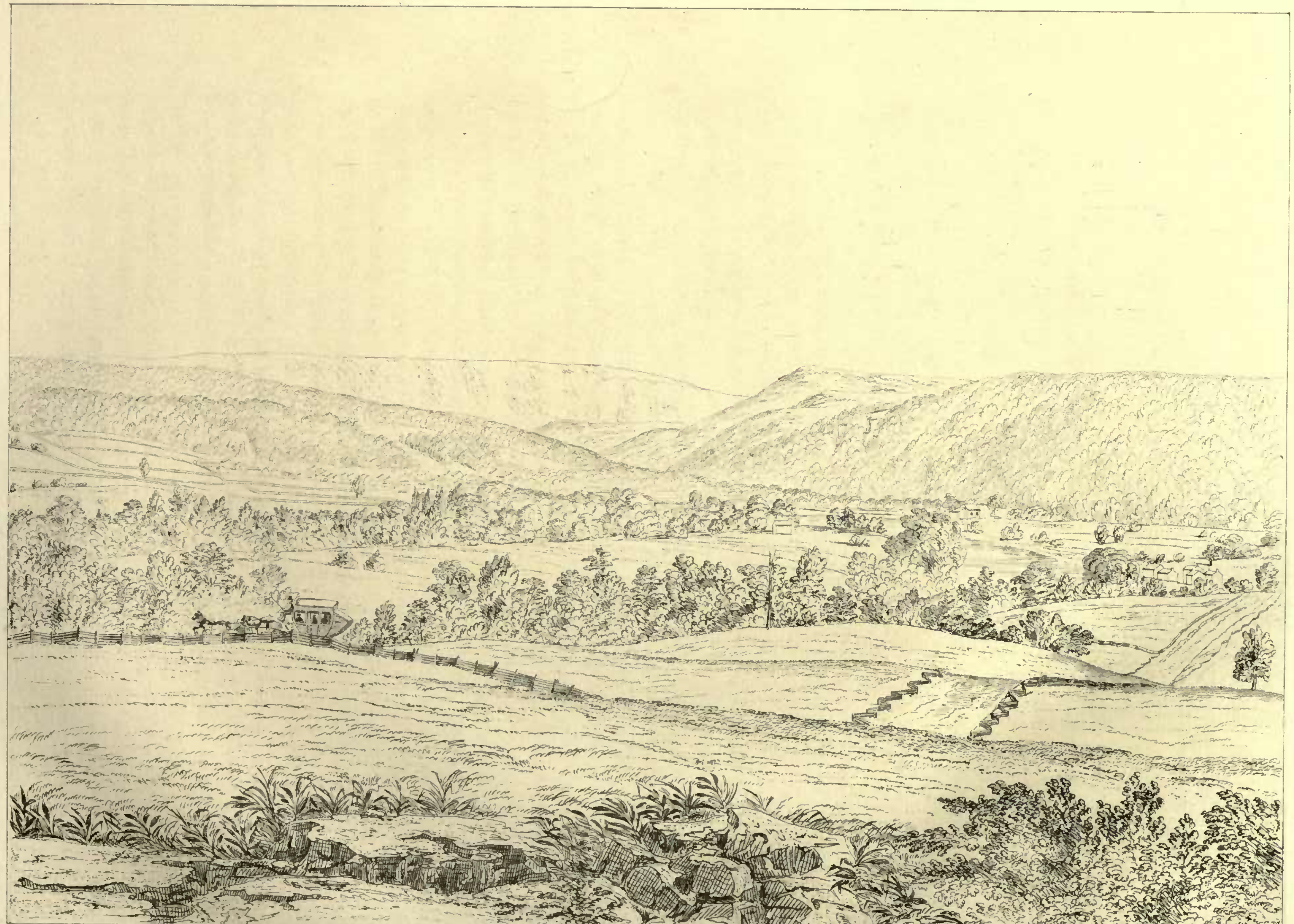
Instances.—Many interesting *examples* of anticlinal ridges, single, double, and triple-crested, occur in the mountain-chain. Among the more prominent may be mentioned Montour's Ridge, between the two branches of the Susquehanna and Tuscarora Mountain, near the Juniata, both single-crested; the Blue Ridge, south of the Juniata in Mifflin, double-crested; and the Shade Mountain, east of that river in the same county, triple-crested for the greater part of its length. Many of the anticlinal spurs projecting from the mountains surrounding the anticlinal valleys are simple or unbroken in outline at their extremities, but further along them their crests divide, and in some cases, where two hard massive strata form the ridge, they carry not two, but four secondary crests. It is recommended to the reader to inspect with care that part of the geological and topographical map which represents the mountain-chain south-west of the Susquehanna, where he will detect all the above-described and many other curious phases in the topography.

Where an anticlinal wave of hard resisting strata is so far eroded along its summit as that the ridge formed by it carries a groove or shallow valley along its crest (and such is the case with the Tuscarora Mountain and the Blue Ridge on the Juniata), the crest-line of the mountain is not a gradual curve or flat arch, but a nearly straight line, terminating in two gently-descending curves; it is the longitudinal profile of a truncated wave. A fair conception of the side view from a distance of an anticlinal ridge, deeply excavated into a valley, may be got from the picture given of Millikin's Cove, as it appears from Dry Ridge.

2. *Synclinal Ridges.*—Ridges and hills of the synclinal structure are almost equally numerous with those of the anticlinal form, existing, in fact, wherever energetic denuding waters, acting on alternately-resisting and easily-worn strata, have cut away the harder masses from the convex waves of the crust, and left them only in the troughs or the concave parts. There they often stand forth in bold relief above the anticlinal valleys, composed of softer materials, trough-shaped in the curvature of their strata, yet mountains in their elevation above the general level. Previous to the denuding action, such ridges and plateaus were the valleys of the waves into which their strata were undulated; but the ridges of those waves having been all swept away, and the soft materials beneath them cut into valleys, these more protected remnants of the harder upper rocks project above the general level.

In some instances these synclinal ridges have narrow and sharp crests; but this is only when their strata dip inwards from both sides at steep angles. Mount Pisgah, near Mauch Chunk (for a view of which, with its inclined plane, see the picture in this work), is a good instance of the narrowness in the terminating crest of a synclinal ridge or basin. Wherever the synclinal dip is only moderately steep, and the hard rocks are in sufficient thickness, the ridge is flat-topped; and if the synclinal trough is broad, and comparatively flat in the bottom of the wave, and its flanks steep enough to oppose the resisting edges of the strata to the waters, we have the ridge spread out into a plateau. In many cases synclinal plateaus, or table-lands of hard formations, occupying the depressions of broad flat undulations, terminate in several subordinate, synclinal spurs or fingers, originating precisely in the same manner as the detached synclinal ridges, from the denudation of the harder strata from off the anticlinal portions of a belt of waves or flexures.

The side aspect or longitudinal profile of a synclinal ridge or mountain is essentially unlike that of an anticlinal one. While the latter is gently convex, unless where its crest is truncated,—and even then its ends are—this species of mountain has a crest-line slightly concave, especially towards its extremities. The anticlinal ridge terminates in a slowly-declining, tapering



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HUNTINGDON & JACK'S MOUNTAIN, FROM WARRIOR RIDGE.

point; the synclinal one rises near its end into a softly-swelling hump, and then falls rapidly away with a bold concave sweep into the plain.

Even where a synclinal mountain or plateau is deeply excavated along its summit, or is but the extremity of a trough-shaped valley, we may still discern this slight rise at the end, and abrupt external slope. It is well seen in the picture of the end of Canoe Mountain in Sinking Valley, the feature appearing not merely in the upper crest but in the terrace below it.

Instances.—All the districts of the mountain-chain present us with examples of synclinal ridges and plateaus. The anthracite basins terminate by the converging of their bounding monoclinal ridges in synclinal spurs; the long and attenuated Dauphin Basin terminates in a very conspicuous one. West of the Susquehanna the synclinal mountains are numerous. Kishicoquillas Valley contains three such spurs, and indeed the whole remarkable mountain-group between the Lewistown Valley and the Valley of Bald Eagle is full of them. Nittany Mountain is an interesting example of one, Brush Mountain is another, and so also is Canoe Mountain, with its conspicuous encircling terrace.

Two pictorial views, one representing the spurs in the eastern end of Kishicoquillas Valley, the other showing the termination of Canoe Mountain, are introduced to give the reader a clearer conception of the peculiar physiognomy of some of the synclinal ridges of the Appalachian Chain viewed endwise.

The picture from Warrior Ridge, of Huntingdon and the mountains adjacent, indicates the very different modes of ending of anticlinal and synclinal mountains. Jack's Mountain in the distance is seen sinking slowly towards the right hand; while Terrace Mountain, the high knob in advance of it, ends abruptly, throwing up a slight hump.

The features of erosion belonging to synclinal ridges and plateaus differ distinctly from those characteristic of the anticlinal mountains. In the one instance the excavation or wash has been across the edges of the strata, or approximately perpendicular to their dip, this being into the mountain, the watery currents from it; in the other, or anticlinal condition, the push of the waters down the slope has coincided partially with the outward dip of the beds. In the first case the rocks have been comparatively protected from erosion, and therefore the ravines and gutters, though relatively numerous, are seldom of great magnitude; in the other, they have been in the attitude to be most easily ploughed up at their outcrops, and hence we find such enormous gashes in those crests and slopes of anticlinal and monoclinal mountains, whose strata thus dip coincidently with the course of the eroding waters.

The S.E. edge of the great table-land which margins the bituminous coal-field of the State, and is called the Alleghany Mountain, is a good example of that excessive erosion visible in all the higher synclinal plateaus and ridges, consisting of nearly horizontal strata. As seen from near Hollidaysburg (see Picture), it displays a remarkable amount of deep trenching from its summit to its base. The Pennsylvania Railroad has its track through one of the ravines here shown, with a grade of 104 feet per mile.

3. *Monoclinal Ridges.*—Monoclinal ridges, or those whose strata all dip in one direction, are numerous in all parts of the mountain-chain. For the most part they are the sides or barriers confining synclinal or monoclinal valleys, and each therefore finds its counterpart in a second ridge on the opposite side of the valley, containing the other outcrop of its own strata dipping to an opposite quarter. Viewed as isolated masses, these ridges are nevertheless

monoclinal, or possess a one-way dip. It is only where the two counterpart crests unite that the resulting spur is synclinal or anticlinal, as the case may be. In all the mountain-chain there is but one narrow-crested monoclinal mountain or ridge of any magnitude which has not its counterpart, or the oppositely dipping outcrop of its strata, within the State, and that is the Kittatinny, the features and great length of which have been sketched already. To make the rule of the basin, or rather the wave-structure of strata, universal—except in districts of original obliquity of deposition—it can be shown that the formations of the Kittatinny Mountain, even to some of their subordinate individual beds, rise again to the surface in the State of New York, in the direction of Lake Ontario, passing beneath our whole mountain-zone, or only rising once to disappear again, as a small anticlinal wave, in Montour's Ridge.

The transverse profile of a monoclinal ridge depends essentially upon two circumstances—the relations as to hardness and thickness of the several beds of rock entering into it, and the inclination at which these dip. The hard rocks will form crests, and the edges of shelves and terraces, and the soft ones, depressions between the crests, and also the floors of the terraces themselves ; a steep or perpendicular dip is accompanied by a narrowness of base and a sharpness of summit ; and by an approximation of the crests, if there be more than one, and it causes the terraces to be slanting and narrow ; a gentle dip, on the contrary, spreads the mountain both at base and crest, converts all but the primary summit into the margins of terraces, and causes these shelves to be broad and approximately flat. From considerations already presented, it must appear that the marks of erosion upon the two opposite flanks of a monoclinal ridge must greatly differ. This may readily be seen by inspecting the map, and some of the plates of scenery. The terraces or benches on the outcrop or basset side of the ridge are usually well defined, wherever the dip is neither too flat nor too near the perpendicular ; whereas on the other, or dip side of the ridge, they are more vague and rounded. It is chiefly in coal-fields, where there is a great inequality in hardness between the sandstones and the coals, and especially in those where the strata have a moderately steep slope, that the benches are clearly discernible on the synclinal aspects of the hills. Wherever they are, they furnish, as in some of the anthracite coal-basins of Pennsylvania, an invaluable key for detecting and tracing the outcrops of the seams of coal. The downward carving or grooving of the opposite slopes of such ridges is likewise very different ; so different indeed, in certain districts, that a shrewd eye, practised in reading the geology by aid of the topography, will oftentimes infer the important condition of dip of the strata by these features of the denudation.

Instances.—Besides the remarkable instance of the Kittatinny Mountain, we may cite as among the well-characterised examples of large monoclinal ridges, all those long, narrow crests next exterior to the mountain-rims, enclosing the anthracite coal-basins, from which they stand, usually, not a mile distant, insulated by a deep valley of soft red shale, and bounded outside by other valleys of equally soft rocks. They are to the inner citadels of fuel like so many outer protecting ramparts. All of these monoclinal ridges are continuous with each other, constituting, in fact, but one line of outcrop encircling all the coal-fields. This is readily seen. We may trace the monoclinal crest from the Kettle Mountain east of Mauch Chunk, through the Mahoning or Second Mountain to Sherman's Knob or Cove Mountain, west of the Susquehanna ; thence through Peter's Mountain eastward, and Berry's Mountain back again westward to the Buffalo Mountain near the Juniata ; and thence again eastward by the Mahantango Mountain to its junction with the Line Mountain, and back westward to the synclinal knob which it forms with the Mahanoy Mountain at the Susquehanna, and again eastward through the latter to the Catawissa Mountain, and from the synclinal knob of this still eastward by the Nescopeck Mountain to the anticlinal table-land, where this unites with the Wyoming Mountain ; and so by this latter crest entirely round the Wyoming and Lackawanna coal-field, from whence we may bring it across in a flat and tortuous outcrop through the table-lands at the sources of the Lehigh, until we enter the Nesquehoning Mountain, and then finally turn eastward and southward round the Kettle to the point we started from.

West of the Susquehanna numerous long and narrow monoclinal ridges encompass the anticlinal valleys and coves of that region all the way to Maryland. These lie in groups, which are more or less complex, and the monoclinals of each group may be seen to thread into each other in a manner very similar to the above-described winding about of the outer ridges of the coal-basins. Those of the great north-western belt of anticlinal limestone valleys, including the Kishicoquillas Valley, constitute one of the most remarkable examples to be met with in the world, certainly the finest case in the Appalachian Chain of this winding into each other of the monoclinal ridges due to the symmetrical disposition of the anticlinal and synclinal undulations of the strata. Commencing with the Bald Eagle Mountain, say opposite Williamsport, we may thread the monoclinal mountain-crest through ten successive anticlinal spurs, and nine alternating synclinal knobs, by a beautifully regular zigzag progress S. to the spurs of Jack's Mountain, in Union and Snyder counties ; thence trace it S.W. as the crest of Jack's Mountain of Kishicoquillas Valley, and back again N.E. into the Seven Mountains; and thence meander it through these into Tussey Mountain, and follow it as the crest of Tussey Mountain to Bean's Cove, at the Maryland State line, and back again N. through Evit's, Dunning's, Lock, Canoe, and Brush Mountains into Bald Eagle Mountain, and along this to the point of setting off. In this belt of anticlinal valleys it will be observed that the outward projecting spurs are anticlinal, and the re-entering ones synclinal; whereas in the anthracite coal-region, where the interior valleys are of synclinal structure, the salient spurs are synclinal, and the re-entering ones anticlinal. And all these reciprocating, topographical features are the simple consequences of the planing down to one general low level of mighty systems of crushed waves, or parallel flexures of the strata ; the waves of the one, or anticlinal region, have had their hard upper rocks worn through into lower softer ones ; the waves of the other, or synclinal coal-district, have had their soft upper rocks cut away into lower harder ones.

Valleys.—As already intimated, the valleys of the Appalachian Chain are of all the three classes which belong to a region of undulated strata ; namely, Anticlinal, Synclinal, and Monoclinal. They are, indeed, but the superficial depressions caused by extensive grooving by water of the same waves of the crust which include the ridges. It is obvious that, as the formations consist of alternately hard and soft, or resisting and removable deposits, a mere difference in the general depth to which the denuding watery currents were able to plane down the crust-waves, into which these strata were undulated at their elevation, would determine for each individual convex and concave flexure whether it would become a valley or a ridge. If at the time of their last retreat, or at that stage when their cutting power ceased, the moving waters were in contact with soft mud rocks, or as yet unconsolidated limestones, they would leave a permanent valley, whether they were just deserting the back of an anticlinal or convex wave, or the bed of a synclinal or concave one ; and if, on the contrary, they were in contact with less removable materials, sandstones and conglomerates, they would leave a permanent ridge or plateau, whether the flexure were an anticlinal or a synclinal one.

Anticlinal Valleys.—Anticlinal valleys are of two classes—1st, Those which terminate in coves, or are enclosed at their ends as well as sides by mountain barriers or ridges ; 2d, Those which are open at both extremities, and are insulated at their sides only, by ridges of synclinal or monoclinal structure. Nearly all the larger valleys of the mountain-zone of Pennsylvania belong to the first class. After what has been already stated concerning the erosion of anticlinal flexures, and the scenery of anticlinal valleys, no further description of them is here needed, beyond a mention of an interesting difference between them and the synclinal valleys in the contour or profile of their beds. While the synclinal basins are strictly trough-shaped, or have their line of greatest depression of surface in their middle or near the synclinal axis of their strata, these anticlinal valleys are for the most part raised in the centre, and have two lines of depression—one at the foot of each bounding ridge. They constitute the class of excavations termed by Buckland and other geologists, Valleys of Elevation, and when elliptical and not too much elongated, the visibly dome-shaped contour of their beds entitles them to this appellation. Being excavations in the summits of convex or anticlinal waves, they may not unfitly be called *Valleys of Elevation and Erosion,* as the denuded synclinal troughs, or those in concave flexures, may be styled *Valleys of Depression and Erosion.* This bulging of the more central tracts amounts, in some instances, where the denuding waters have encountered a resisting underlying stratum at the anticlinal axis, to a positive ridge. All gradations of profile, from gently arching to prominently ridged in the centre, are to be met with in the anticlinal limestone valleys of the mountain-chain west of the Susquehanna. Being well defined by name on the geological map of the State, and by the pale-blue tint employed, it is not expedient in this place to do more than call the attention of the reader to their topographical structure. Their physical features will be fully sketched in connection with the geological descriptions to be given of them in future chapters of this work. The arched form of surface distinctive of the larger anticlinal valleys of Clinton, Centre, Mifflin, Blair, and Bedford counties, and the cavernous structure of the great magnesian limestone formation of which they chiefly consist, combine to divert a large proportion of the atmospheric water they receive, from their higher middle tracts towards their sunken margins. By a drainage chiefly subterranean, these central tracts in Nippenose, Nittany, and Penn's valleys, in Morrison's Cove, and indeed in several others, are seriously deprived of superficial streams, and their soil is dry and barren, while their borders, on the contrary, are most copiously supplied with gushing springs and large brooks of filtered, sparkling water. So deficient in irrigation, and therefore unsuitable to agriculture, are the central high grounds, that they usually go under the name of " The Barrens." Their soil is for the most part sandy, being derived from the disintegration of the very arenaceous lower beds of the magnesian limestone, and no doubt this quality concurs with the underground drainage above adverted to, to give them their prevailing sterility. It has been proposed to seek a remedy for this by sinking artesian wells, and in one or two instances sufficient supplies of water have been thus procured to render farming profitable, where previously it was not practicable. It is manifest, however, from the facts here stated, that the geological conditions are adverse to the procuring easily of a full supply of the subterranean water by such artificial means ; the anticlinal or arching dip of the strata, and their cavernous nature, being most inimical to the success of artesian wells. Positions may be found, however, on the slopes of these barrens or central ridges, where the water will rise nearly to the surface by its own hydrostatic pressure ; and in some anticlinal tracts there is a flatness, or actual basining of the rocks at the summit of the anticlinal arch, which, where it exists even locally in these valleys, may sometimes, despite the multitudes of fissures and caves in the limestone, render artesian borings profitable.

The picture of Millikin's Cove, from Dry Ridge, displays at a glance the extent to which the waters were able to scoop out a valley in the crest of an anticlinal wave.

Synclinal Valleys.—Like the anticlinal valleys, the synclinal are of two classes ; those which are encompassed by a rim of hard strata, and those which are open at one or both extremities. The several anthracite basins are good examples of the class of closed synclinal valleys both straight and curved, and both simple and complex in structure. The basin enclosing the coal-field of Broad Top Mountain, in Huntingdon and Bedford, is another good instance of a symmetrical yet complex valley of this class. Many lesser ones will be mentioned in the detailed description of the geology. A curious example is the mountain-basin of Scrub Ridge, in Fulton County ; this valley being a shallow depression within an insulated mountain-plateau, ruptured at one side by a deep ravine.

Of the other class of synclinal valleys, or those not enclosed at either end, there are several striking examples within the mountain-chain. One of the largest of these is the long valley or narrow plain which commences at the Susquehanna, opposite the western end of the Mahanoy Mountain, and ranges across the Juniata, as the valley of Tuscarora Creek, to the end of Scrub Ridge, above referred to. This may be regarded as a prolongation of the same synclinal trough, which embraces the Shamokin Coal-basin. Another very similar valley of the same structure is traceable through even a longer distance from the Catawissa Mountain, in Columbia County, across the Susquehanna, at the junction of its two great branches, and thence through Snyder, Huntingdon, Mifflin, and Fulton counties, even into Maryland, between the Black Log and Shade group of anticlinals on its one side, and the anticlinal ridges of Montour's Ridge and Jack's Mountain on the other. Its central portion is called the Lewistown Valley ; and as it is there obstructed by several local ridges, the whole may be as properly viewed in the light of a chain of valleys as in that of one single continuous trough. There is nothing especial in the scenery of this class of valleys to call for particular description.

There is a subordinate class of valleys allied to these—valleys which are open only at one end, and usually forking there into two branches, and closed at the opposite extremity by ridges, or the summit of some anticlinal plateau. These may appropriately be called Synclinal Coves. A brief inspection of the topography shown on the geological map of the State will display the positions of a number of such half-shut-in valleys of all dimensions. Several large ones will be seen opposite the western terminations of the anthracite coal-basins, and the reader will note a series of them in Union County, penetrating westward from the general plain of the district, between the beautifully symmetrical anticlinal spurs, in which the mountains of Mifflin and Centre counties there terminate.

The scenery of these coves is usually striking and attractive, from the exquisite regularity of the curves by which the bounding ridges slope down into the bed of each glen, or further out into the plain that forms the middle distance of the picture.

There are two kinds of these open synclinal valleys,—one terminating, as in Union County, in a level country; the other subdividing or forking by the introduction, near their mouth, of a synclinal ridge or mountain, which itself is sometimes but the terminal knob of another synclinal cove of similar structure. Our map displays near the Susquehanna three interesting examples of this arrangement of spoon within spoon, opposite the terminations of the three first coal-basins—those of Dauphin, Wiconisco, and Shamokin. The two branches into which each synclinal cove, thus divided in its middle by a mountain basin, bifurcates, are both of them monoclinal valleys, or valleys, all the strata of which dip in one direction—that is, towards the synclinal axis of the parent valley prolonged.

Monoclinal Valleys.—The third class of valleys consists, according to our joint topographical and geological classification, of those in which, as above stated, all the strata dip in one direction. In a region so regularly undulated as the Appalachian Chain, they are almost invariably very long and slender, and of uniform average width; they are, indeed, merely excavations or deep trenches on the sides of the anticlinal or synclinal waves, and not on their summits or in their troughs, as are the other two kinds. Wherever the formations are greatly contrasted in their capacities for resisting the scooping power of moving water, these valleys are proportionately deep below the parallel crests which confine them, but in the same group of formations they are relatively narrow or broad, according to the steepness or flatness of the dip of the rocks, while their height or level above the average plane of the country is the greater in proportion as this dip is less. The chief variety of feature to be met with in these valleys is in the carving of the slopes of their bounding ridges. In many instances this is very beautiful and picturesque, especially where the valley is large and very long, and confined by mountains, whose crests possess a gentle curve. If, in such cases, the observer stands on some buttress or more projecting station midway up either slope, he may often feast his eye upon a long superb perspective of indented mountain-sides. For a reason already intimated, the ravines and terraces of the two enclosing barrier-ridges will offer essentially different profiles: the one set, belonging to strata dipping away from the valley, will be sharply escarped and trenched; the other, pertaining to beds of rock dipping into the valley, or with the slope of their own side of it, will be more delicately and faintly grooved and modelled; and thus a rich diversity of contour is frequently to be seen, where the topography is of the simplest kind, and the geological structure, or dipping of the strata, undergoes no change.

We get a good view of a monoclinal valley, that of the Mauch Chunk Creek, between the Mahoning and Sharp mountains, from a buttress of the latter, called Mount Jefferson, at the head of the inclined plane of the Mauch Chunk Railroad.

Instances.—By far the longest valley of the monoclinal class is that which lies immediately N.W. of the Kittatinny Mountain. In strictness it stretches the whole distance from the Hudson River at the end of this mountain, which in New York is called the Shawangunk Range, to Perry County, west of the Susquehanna. Throughout its N.E. half, where it is bounded N.W. by the Pokono Mountain, and the whole way thence to the Schuylkill, it is a somewhat broad belt, and contains generally at least one subordinate anticlinal flexure, so that rigidly it is not a monoclinal valley. Toward its western end, however, it contracts, and runs to its termination without any deviation in its strata from their usual steep north-west inclination. This valley contains much fine scenery of the kind characteristic of its class, additionally diversified by the presence, on the one hand, of bold spurs entering it from the Kittatinny Ridge, and, on the other, by great bastions of the Pokono.

Next in magnitude is the long curving valley immediately at the S.E. base of the Alleghany Mountain. This begins in Lycoming County, with the rising of the Bald Eagle Mountain, which confines it on one side. There, and in Clinton County, it is watered by the broad and placid Susquehanna, and by several large tributary streams entering it through deep passes in the plateau on its north. Further forward to the S.W. it leaves its graceful curvature of line, and runs almost absolutely straight between the Alleghany Escarpment and the sharp crest of the Bald Eagle Ridge, nearly to the termination of the latter in Blair County. Throughout this central part of its course it possesses the monoclinal structure on a scale of grand simplicity. Turning more southward in Blair, the valley widens by a curious offset in its mountain barrier at the ridge called the Lock Mountain, and further on it dilates again by another offset of the same ridge near Bedford. The rising of Wills' Creek Mountain presently reduces it, however, to its average dimensions, and approaching the State boundary of Maryland, it divides into two branches, losing its monoclinal structure by the admission of the synclinal basin of the Potomac Coal-field. In Lycoming and Clinton this grand deep trench in the strata embraces a few trivial undulations which modify its topography, diversifying its northern and central tracts, with a few small picturesque ridges of limestone. Again, in Bedford County, the introduction of one or more short waves of the strata, near the foot of the Alleghany Mountain, causes the presence of more than one knob and stony-crested ridge. Besides these more marked exceptional features, the valley exhibits throughout its entire N.W. border, a multitude of low hills, carved from out the base and lower slope of the Alleghany Mountain. These are well shown in the picture of the front of the Alleghany and the country at its base, taken from near Hollidaysburg.

It is not necessary to enumerate here the many long and slender monoclinal valleys which begird the anthracite basins, like so many moats enclosing walled cities. The geological map exhibits them in all their curious symmetry, and the descriptive details hereafter to be given will set forth their more special features. Wherever there exists a basin within a basin, or one anticlinal valley within another, two such monoclinal valleys, one on each side, will be seen to occupy the spaces between the rims of the inner and the outer ridges.

DIFFERENT CLASSES OF SCENERY IN THE MOUNTAIN-CHAIN, AND THEIR RELATIONSHIPS TO THE PHYSICAL GEOGRAPHY AND GEOLOGY OF THE REGION.

The kinds of scenery most characteristic of the larger anticlinal and synclinal valleys have been already alluded to, but it will be instructive to sketch succinctly the several classes of natural pictures to be met with in the Appalachian Chain, with somewhat more of geological method, avoiding a repetition of what has been already described.

Scenery commanded by Anticlinal Mountains.—Beginning with the views distinctive of the anticlinal belts—mountains and valleys—we will, in the first place, conceive ourselves standing on the summit of a simple or unbroken, long, narrow, anticlinal ridge. Stationed anywhere near the central swell of its crest, and commanding an unobstructed sweep of vision, we may usually behold a very interesting panorama of mountains. Looking across the chain in either direction, the eye descends the long, beautifully-curving, flattening slope of the mountain-side from a craggy foreground, over gnarled and wind-distorted trees of stunted growth, to timber growing progressively denser and richer, till low towards the foot, and in the valley, the forest spreads away in broad and dense luxuriance. Beyond the adjacent valley or narrow plain rises a counter-slope of another mountain-ridge similarly clothed with woods, and ending in a stony crest of nearly equal elevation with the summit we are upon. Our position is, however, somewhat higher than the crest-lines of the monoclinal and synclinal ridges around us, and the eye travelling across them, and through the notches which here and there indent them, or beyond their points, sees ridge succeeding ridge, and valley behind valley, grouped in a far-receding perspective, like majestic waves on a storm-tossed ocean. The upper slopes of the mountains being for the most part clothed with forest, this resemblance to some vast sea, heaved into enormous billows, is rendered all the stronger from the monotony of the colour which clothes the wide scene. It is only in the nearer distances, especially in the valleys beneath us, that this monotony of tone is relieved by other brighter tints, by clearings, cultivated fields, the rich browns of the ploughed earth, and the gayer green of the meadows. It is delightfully interrupted by a feeling akin to surprise when the eye catches sight, through some deep notch or opening, of a patch of cultivated valley, with its farms and dwellings smiling in the sunshine amid the dusky green of the seeming wilderness.

Let us now suppose that the beholder, sated with these broad mountain-top views, turns to gaze in the direction of the trend of the crest upon which he is standing, or towards the north-east or the south-west. To open these longitudinal views from foreground obstructions, he will usually travel along the summit and station himself somewhere upon the long drooping end of the mountain, though at as high a level as possible. There he will be greeted by a scene which seldom fails to interest and delight him. Very different from the previous, it is a picture of long receding valleys instead of opposing mountains. Centrally in the nearer parts of the landscape is the regularly-tapering forest-clad ridge upon which he stands, and beyond it a wide noble panorama, formed by a girdle of mountains, converging to the distant vanishing-point of the picture in a swelling peak, or gracefully rounded summit, the highest object in view; and all between this background and the hill on which he is stationed, the more or less cultivated plain or valley stretches before him, and dividing at the lower point of the ridge, passes to the right and left of him. He is looking, in fact, towards the head of a great anticlinal cove between the mountains, along an anticlinal valley many miles in length, which, bounded by symmetrical mountain-slopes, opens towards him, and divides at his feet. In some instances, as in Centre and Mifflin Counties, these coves are simple, and we look along but one slender valley closing up in the distance; but this style of scene has many modifications, and there are numerous examples where, besides the principal valley stretching in front of us, we look forward past the ends of synclinal ridges, right and left, into other parallel plains. Of this character are the beautiful semi-panoramic pictures to be seen whenever we are at the trouble to ascend to some high clear spot on the N.E. point of Shade Mountain, in Snyder County, or to a similar position on the Tuscarora Mountain, in Juniata. A little study of the topographical features represented on the map, will suggest many other choice points of view of this description; indeed, there is scarcely an elevated anticlinal ridge within the portion of the chain west of the Susquehanna which does not, from one or both of its extremities, command a superb view of valleys and their bounding ridges, seen in the direction of their length in prolonged perspective.

The interest belonging to this class of scenes is frequently much enhanced by a singular structure in the ends of the anticlinal mountains, from whence the beholder is supposed to be looking. Through geological causes, hereafter to be explained, the point of the mountain, instead of tapering off simply and smoothly, sinks with a beautiful crest-line to a certain spot, and there ceases, plunging, as it were, into the centre of a little crescent-shaped or horse-shoe valley, which closes around it, and projects its two horns or prongs backwards, to coalesce with either base of the mountain. Where the mountain ends somewhat bluntly, as the Shade Mountain in Snyder, and Jack's Mountain in Huntingdon, do, this crescent-like rampart in the foreground of the picture, steep and often craggy on its inner slope, and smoothly declining on its outer, is a beautiful addition to the scene. Where the mountain terminates acutely, as the Tuscarora Mountain does at its S.W. extremity, or as the Black Bog and adjacent Blue Ridge do at both ends, the appended ridge has, in its ground-plan, almost the form of a long and slender dart, projecting a keen point into the valley, and its two barbs, backwards, towards the main ridge.

There is another interesting class of scenes commanded by the anticlinal mountains, in which long anticlinal valleys or coves terminate. These points of view are the peaks or swelling knobs before spoken of, as occupying the middle points of the pictures, beheld by looking from the ends of anticlinal spurs up the anticlinal valleys. Let the reader, studious of interpreting the relations of the scenery of the mountain-chain to its topography, imagine himself standing at the head of either of the anticlinal coves which intervene between the western ends of our anthracite coal-basins. Let him, for example, stand at the junction of the monoclinal ridges, Peter's and Berry's Mountains, or at the union of Mahantango Mountain with Line Mountain. He will observe two very different scenes, as he gazes eastward or westward. Eastward, he beholds a picture very similar to those before described, as seen from the ends of the insulated anticlinal ridges, only much more circumscribed, for he looks into a short anticlinal cove forking to his right and left into two narrow monoclinal valleys. But westward he gazes over a landscape of far wider scope; he sees the two monoclinal ridges, at whose elevated point of junction he is standing, diverge and recede before him in gentle curvature, like the bulwarks of a great ship viewed from the end of the forecastle; while subsiding in front of him there stretches a long, expanding valley, hilly, and covered with wood in its nearer, narrower end, but smooth, cultivated, and gay with farms and villages in the distance; and he catches here and there the silvery surface of one or both of the main streams which flow from him along its margins, or perhaps that of the main Susquehanna River itself. Centrally, in the background of the scene, appear the ends of high-swelling anticlinal mountains, on the extremity of one of which we have before supposed him stationed, and gazing towards the very spot from which he is now looking.

If our traveller, still restricting his attention to the commanding points of view afforded by the high anticlinal ridges and knobs of the country, chooses, in the same district, one of the points of junction of the monoclinal ridges which immediately invest the anthracite coal-basins, shifting his station from the outer to the inner barrier of the coal-field,—if he chooses, for example, a spot on the high anticlinal plateau west of Tremont, or any similar geological locality,—he will have before him a very curious and interesting scene. At the head of a crescent-shaped rim of mountain, he gazes into a deep crescent-shaped valley called "the Kettle," and across the middle of this beautiful valley, looks upon a broad, swelling, anticlinal mountain, the very same upon which he had his previous station. The deep moon-shaped valley before him throws forward its two horns to embrace the broad mountain in front of him, each running indefinitely into the distance, as a straight and narrow monoclinal valley between two sharp-crested monoclinal ridges, into which the anticlinal knob soon diverges. If his perch is high enough, he can look along their narrow summits, and into the valleys between them, counting four mountain-ridges and three enclosed valleys. In the middle of the wide picture he catches a distant view of the expanding anticlinal plain or valley, which nearly filled the scene at his previous station, and right and left of it he beholds the narrower side-valleys prolonged from the crescent-shaped " Kettle " below him.

If, instead of selecting a series of stations on the broader anticlinal waves of the surface, our traveller chooses his points of look-out at the head of one of the slender limestone coves west of the Susquehanna, he will meet with a series of views very similar in their general features to some of those just described, but differing in the comparative slenderness of the valleys along which he will gaze. Planting himself back from the immediate head of one of these coves upon the next ridge, as he did in a previous instance, he sees before him, not a deep crescent-shaped Kettle or valley, but a very interesting crescent-shaped plateau, or mountain-floor, or upper cove, beyond which he looks into the lower principal one. Some of these mountain-coves in Centre and Union counties are indeed somewhat depressed at their ends, and therefore approach a little the anticlinal "Kettles" in their scenery and topography; and in truth the industrious explorer of these features of the chain may find them of every gradation, from deep "Kettles" to high level crescent-shaped mountain table-lands, as the conditions of stratification permit. If the soft stratum forming the excavation is very thick, and the dips moderately steep, a wide deep valley is the consequence; if it is thin relatively to the hard formations embracing it, and the anticlinal flexure is gentle, an elevated crescent-shaped plateau is invariably met with.

Scenery from Synclinal Mountains.—The kinds of scenes visible from the summits and sides of the straight-backed and level synclinal and monoclinal ridges of the Appalachian Chain are, for the most part, so identical with those already described, as seen from the tops of the anticlinal ridges, that it would be superfluous to attempt to depict them. Nor is it necessary to sketch the features of those which are beheld from the terminal synclinal knobs or basins, looking outwards into the valleys and plains, further than to indicate wherein they differ from the scenes beheld from the points of the anticlinal ridges. We have seen that the latter, embracing great longitudinal views of the anticlinal valleys, are bounded by the ridges which enclose and terminate these coves; they of course take in the most terraced slopes of the adjacent mountains. The other class of scenes, or those of the synclinal belts, likewise sometimes terminate in cove-shaped valleys, though they more frequently look out into plains and valleys which are not closed in the distance by any converging ridges. The terminal knobs of the synclinal basins being loftier than the drooping points of the anticlinal ridges, these first-named stations offer altogether the widest and most panoramic mountain-pictures to be grasped by the eye; and they have this further superiority over the other class of summits, that they control unobstructed views in all directions outward from the basins to which they belong, into the longitudinal plains included between the receding anticlinal summits in one direction, and inward in the other, to embrace the features of the mountain-troughs at the ends of which they are seated. The outward view, or that which we get upon gazing off from the synclinal basin, whether it embraces a cove or an unclosed valley receding to the horizon, shows the anticlinal mountain-slopes in their least indented and terraced aspects, unless where these slopes belong, as in the case of the Tuscarora, Shade, and Blue Mountains, to ridges grooved along their crests, when they are deeply notched and ravined. In such instances the perspective is very fine, as the reader may infer from inspecting the picture of the Lewistown Valley, and such others as show the indented flanks of the ridges of this order. Another characteristic feature of these scenes is the deepness of the valley in the front of the picture, or that in which the synclinal knob terminates. Ending more abruptly than the anticlinal spurs, these synclinal mountains usually overlook steeper slopes and deeper valleys on their outer sides.

Some of the most commanding points of view of this class are the terminal knobs of the several Anthracite Coal-basins; but precisely as we found, in the anticlinal stations connected with these basins, two different classes of commanding summits—one set belonging to the exterior rim of mountains, the other to the interior rim, or that immediately enclosing the Coal Valleys,—so here, we find among the synclinal knobs two similarly related kinds. Each description of summit commands, of course, two classes of scenes, one in the direction *from* the Coal-basins, the other in that *towards* them.

Views from the Ends of the Exterior Basins.—Let us, for the sake of more clearly understanding the scenery connected with the great synclinal belts or basins of the mountain-chain, conceive ourselves standing on any one of the five terminal knobs in which the outer monoclinal ridges encircling the coal-fields unite towards the west—namely, upon the ends of the Cove Mountain, the Buffalo Mountain, the Mahanoy Mountain, the Catawissa Mountain, or the Shickshinny or Knob Mountain; or suppose ourselves in a corresponding position to the Broad Top Coal-field on a knob of Terrace Mountain, or that of the Harbour Mountain. From either of these high stations we can command one view *from* and another *towards* the coal-field to which the mountain-barrier is related. The outward view is wide and panoramic, embracing, in the middle of the picture, a long synclinal plain, extended, with gradually-narrowing borders, almost indefinitely before us, or finally closing by the approximation of the anticlinal ridges which confine it. To the right and left of the picture lies a broad valley, formed by the forking of this broad synclinal plain, at the base of the knob upon which we stand. All the mountain features, enclosing the main valley and these its two branches, have the soft curving lines, and graceful smooth slopes, distinctive of anticlinal ridges or convex undulations of the strata.

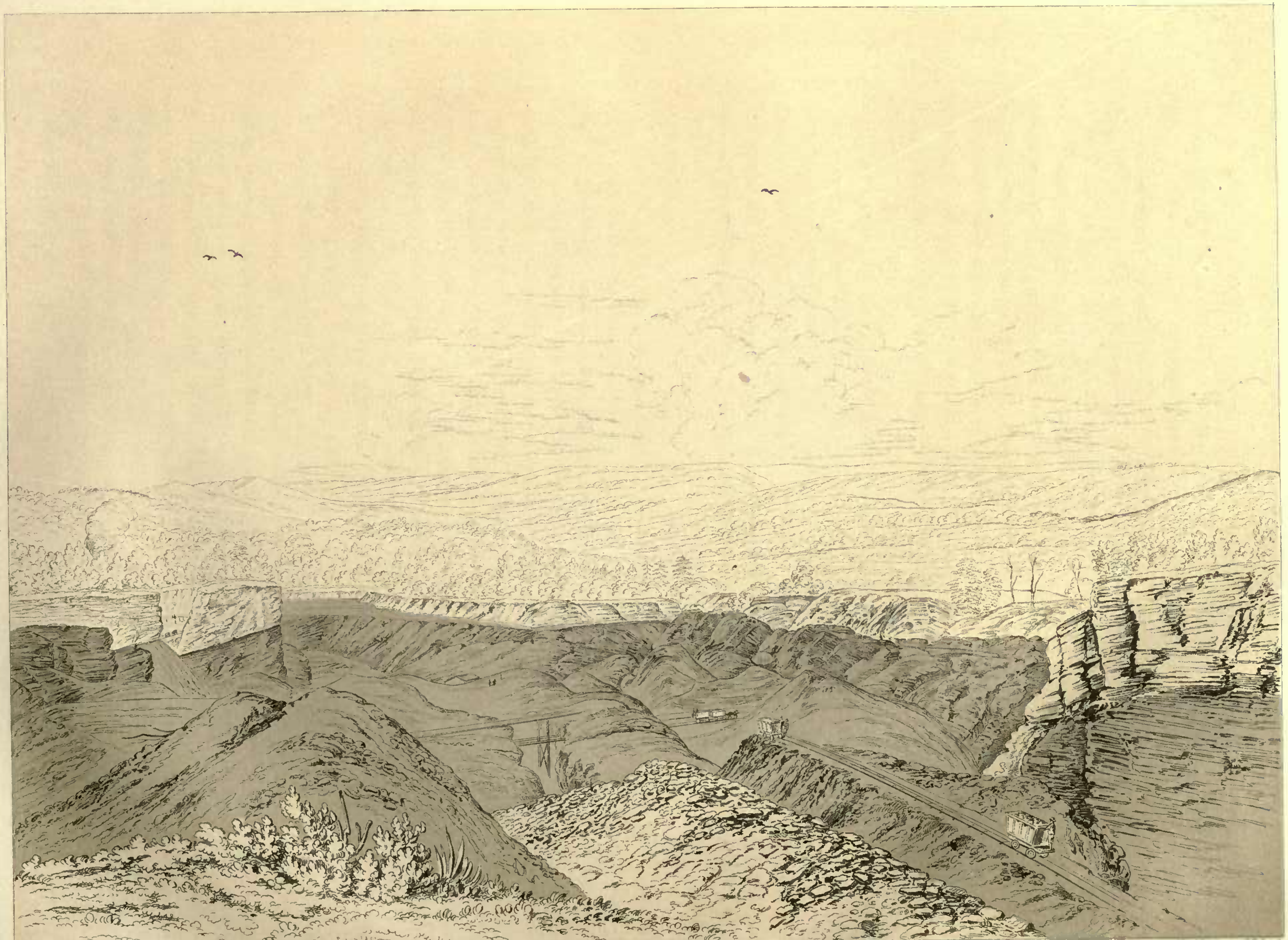
The inward or other view is wholly different: usually far less comprehensive, it is much more curious and striking. In nearly each of the localities mentioned, the station is sufficiently elevated to enable us to embrace, at one glance, the entire structure of the mountain trough, upon the extremity of which we are perched. From our very standing-place, the high mountain-knob slopes down in a majestically flowing curve, first softly convex, and then concave; and on either side it expands, throwing out two wings, which, descending and contracting in breadth, sweep, bending away, till they become two sharp, craggy, monoclinal crests. As the bed of the valley descends, these enclosing ridges sink also, but more slowly, and grow narrower, straighter, and more parallel; and now we behold a structure which may be aptly likened to the bow of a stupendous boat, or to a huge cradle built for holding and launching some colossal ship; the difference in the dimeusions being, that here miles answer to fathoms. This ability to scan with one look the vast natural trough; to gaze downward along the high mountain-walls which enclose it, to behold all the planking of the ship's great hull; the graceful divergence of her bulwarks, the beautiful convergence of her sides towards the central line or keel, and her far-stretching length, never fails to fill the beholder with a sense of elation and surprise. But the scene here sketched carries this curious resemblance no further than to the middle distances; for within a few miles, and in some instances at a less space, there rises in the centre of our fancied boat a mountain-knob, the synclinal termination of the enclosed coal-basin, and from this spot forward the outer trough is parted into two contracted monoclinal valleys, the same which have been already described as branches of the beautiful crescent-shaped anticlinal valleys designated "Kettles." The inner basins, or those immediately embracing the coal strata, containing no such central features, but being trough-like throughout, present, when seen from their terminal synclinal knobs, this resemblance to a ship or boat far more exactly. To the description of these we shall come presently.

Views from the Ends of the Interior Troughs or Coal-Basins.—Shifting our position along any of the synclinal belts, including the narrow coal-basins from the termination of the outer mountain-barrier to the end of the inner one, or that belonging to the immediate rim of the coal-field, we enjoy, as in the previous case, a view of two remarkable but very different scenes. One of these we behold when we look from the coal-field into the synclinal cove which encompasses the mountain summit upon which we stand; the other opens itself on gazing in the opposite direction into the coal-basin itself, which stretches away, descending and expanding, almost from the spot we occupy.

The first or external picture is that of a symmetrical cove, bounded and closed by two converging mountain-crests. Stationed in the centre of the trough, we look along the valley and see its bed gradually contracting and rising as it recedes from us, until it lifts itself like the stem of a sharp canoe into the high peak which bounds our view in the distance. The scene is very analogous to that already described, as visible from an anticlinal ridge, when we look lengthwise into an anticlinal cove, with this difference, that we are standing on a loftier point, and behold a much more boat-like contour in the bed and slopes of the valley before us. The whole carving or modelling of the valley is different; it has the softness and delicacy of curve characteristic of the synclinal structure, due to an accordance between the slope of the strata and the slope of the waters which cut them; whereas the valleys and coves of anticlinal structure are more boldly seamed and distinctly terraced, through the reverse relation of the dip of the strata to the course of the scooping waters.

One of the finest of this class of views is that from the end of the Dauphin Coal-Basin; another is that of the Valley of Zerbe's Run from the end of the Shamokin Basin, and a third is from the top of Mount Pisgah into the Lehigh Kettle.

The other or interior scene, that of the inner valley or coal-basin, is, in its simple grandeur, perhaps the most impressive of all. Standing on any of the mountain-summits in which, by the closing together of their narrow barriers, either the Schuylkill, the Shamokin, or the Wyoming coal-field terminates, and looking into those valleys, the beholder sees a structure singularly like the deck and bulwarks of a gigantic ship scanned lengthwise from the bowsprit; his point of view is relatively as high above the crests of the ridges which diverge right and left from him, and then trend away nearly parallel for miles towards the waist



Lehman. W. & A. K. Johnston, Edinburgh

PART OF SUMMIT MINE OF LEHIGH C^{oy}

Looking West

of the symmetrical skiff-built valley, as when upon the stem of an actual vessel he plants himself on the butt of the bowsprit, and overlooks the taffrail, the forecastle, and the deck. Of this class of scenes none are finer than that from Mount Pisgah, near Mauch Chunk, into the Lehigh Basin ; that from the end of Bear Mountain into the Wiconisco Basin ; that from the knob of the Mahanoy Mountain, looking into the Shamokin Basin, and that from the Shickshinny Mountain, gazing into the Wyoming Coal-field. In some cases a shoulder or platform on the inner side of one of the bounding ridges of the trough-shaped valley projects sufficiently forward into the valley, and is high enough, to afford a fine general picture of its interior. Such a view of the eastern half of the Pottsville Coal-basin, or first Great Coal Valley, is procurable from the Lehigh Summit Mines looking westward. It is especially instructive in displaying the slenderness of the mountain barriers of the valley and the narrowness of their crests. The Locust Mountain and the Sharp Mountain are well seen in profile at the notches or gaps through which the Little Schuylkill enters and passes out of the basin. (See the Plate.)

SCENERY AND STRUCTURE OF THE MOUNTAIN CRESTS.

Having in the foregoing paragraphs sketched the general features of the several kinds of scenery visible from the anticlinal and synclinal summits, it will be instructive, before leaving these and descending into the valleys and the passes through the ridges, to look at the crests of the ridges themselves.

1. *Anticlinal Crests.*—The mountains of anticlinal formation, when not truncated, have their crests usually very smoothly and regularly rounded. They are wider for the most part than those of the monoclinal ridges, but narrower than those of the synclinal, and they are commonly less flat than either ; indeed, every portion of the top may be said to have some curvature. Their local topography is therefore not interesting, though the distant views they command are unobstructed by any inequalities in the foreground. But when truncated or trenched along their crests, their local scenery is oftentimes pleasing and curious. If the tourist wishes to explore such a mountain, with a view to a knowledge of its topography and its geological contents, he will set out at one extremity, ascend the crest-line along the anticlinal axis to the high point where the crest divides, and the long oval valley or spoon-shaped mountain-basin begins, and there pause and scan the exquisitely beautiful curvature of the lines of the surface of the shallow mountain-vale. If the anticlinal structure is symmetrical, in other words, the two slopes of the anticlinal curve of the strata nearly equal, he will perceive a remarkable evenness and equality in the soft slopes of its two borders. If the ridge is denuded of its timber, he may, from his high station, see along its entire length, and grasp the beautiful oval curve of the narrow crest or ledge which encircles it. In some instances it will have the regularity of a most accurately carved, shallow skiff ; in others, one or both of its sides will be notched, and opposite to each opening will occur a depression in its bed. Not unfrequently the converging slopes of this trough in the top of the mountain will descend towards each other by successive stages, and not continuously, and the terraces corresponding in height, and looking like the benches in a boat, will suggest the similitude to a skiff still more strongly. The explorer may follow the central line or anticlinal axis through the middle of the high valley, and there examine the lowest strata which the denuding waters have been able to cut into upon the back of the uplifted wave ; and to seek the very lowest, he will go to

the depressions opposite the lateral notches. Again he may walk along either of the narrow crests enclosing it, and obtain superb views of the external country, and, by merely turning his head, find relief from the fatigue of a vast and complicated picture, in the simplicity, quietness, and home-like nearness of the little mountain-valley at his side. Following the more unbroken of the two crests, if one of them is notched, he will pass in succession the points opposite the openings in the other, when his eye, previously hemmed in by the rim of the valley, which is seldom more than two or three hundred yards distant, will catch with surprise and pleasure the far-off plains and hills, with their brightly tinted farms and houses, and frequently a shining river. Such are the contrasts which refresh the geologist while toiling along the summit-ledges of the anticlinal ridges which so abound in the Appalachian Chain.

2. *Synclinal Crests.*—The tourist finds the ascent of the synclinal ridges more abrupt and arduous than that of the anticlinal ones. He meets with some, retaining a simple, narrow, straight crest-line for many miles. There is one such, called the "*Dividing Mountain,*" between Path and Anderson's Valleys in Franklin County. The slender terminating ridge of the Dauphin Coal-basin is another; and the Hole Mountain, in Lebanon, a third; though few of them are like the latter, insulated from other ridges. In the great majority of instances, the single-crested hills of synclinal structure are merely long spurs, separating anticlinal valleys, and expanding into basins by the division of the crest into two monoclinal ones. The styles of scenery visible from both the terminal knobs, and from the points of bifurcation of these high synclinal spurs, have been already sketched. But some of the synclinal ridges have the form of long and very narrow mountain-troughs; that is to say, they have been truncated, or hollowed at their crests into slender oval basins, bounded by two adjacent, parallel, monoclinal ledges. A good example of this structure is to be found in the ridge in Franklin County, terminating in Parnell's Knob. The local scenery of such a trenched synclinal summit is very analogous to that already depicted as belonging to the similarly truncated, anticlinal mountains. The slender, elevated, oval valley has the same spoon-shaped terminations, and the same notches in one or both of the barriers confining it. It differs chiefly in showing no platforms or benches on its slopes, and presenting altogether smoother and softer concave lines.

3. *Monoclinal Crests.*—The mountain summits of the monoclinal ridges, when longitudinally explored, are fully as interesting as those of the other classes. They indeed abound in a richer variety of immediately local pictures. This diversity mainly depends, however, upon geological conditions, that is to say, upon steepness in the dip of the strata, and especially upon a wide difference in the relative hardness or susceptibility to erosion of the materials of the mountain.

Where these are nearly homogeneous, the crest is for the most part monotonous in its features, being simply rounded like that of an unbroken anticlinal summit; but where they are in strong contrast, the mountain-top is full of variety. To picture more clearly the appearance of these crests, let us suppose ourselves tracing one of those which bound the southern or middle anthracite coal-basins, where an extreme difference of hardness exists between the massive conglomerates and sandstones, and the thick coal-beds and clay-rocks, all composing the Lower Coal-measures. We will imagine ourselves proceeding westward, along either the Sharp Mountain or one of the ridges enclosing the Wiconisco or the Shamokin Basin. The average width of the actual top of the mountain is seldom more than 100 yards. It is frequently much narrower. This top is approximately level, but it is picturesquely broken up into a succession of long narrow floors or strips of smooth surface, each seldom more than 30 or 50 feet broad, standing at slightly different levels, and separated by long, narrow, jutting crags, or ribs of hard and naked sandstone or conglomerate, broken at their outcrops into enormous blocks. Pursuing a zigzag course across the summit from one smooth floor over a strong reef to another floor, we soon ascertain which is the highest ledge, and gazing thence, we are able to mark the exact profile or configuration of the mountain-top. Stretching before us and behind us, are usually three, or four, or five of these nearly horizontal floors or terraces, each with its supporting craggy rib of conglomerate. The perspective is extremely curious and picturesque. If a sparse growth of gnarled chestnut oak, black oak or chestnut, shades as usual the summit and sides of the mountain, we behold long vistas or alleys among the trees, marked out by these alternating smooth and rocky strips. Shifting our position to a ledge on the outer verge of the mountain, we overlook an extremely steep and stony slope, and may discern one or more similar, but less level and well-defined benches or terraces at different levels below us, and beyond these a progressively smoother surface, growing steadily flatter, and covered with a denser forest all the way to the base. If now we cross the crest to the brow or shelf, looking into the basin, we behold a much less steep and rugged flank; the benches are more numerous—each marks the outcrop of a bed of coal—but they are slanting, and comparatively indistinct, and the bushes and trees are thicker upon them. Advancing along the top of the ridge, and choosing for our path either the highest smooth floor or the top of the most projecting stony rib, we follow it for a distance, perhaps of some hundreds of yards, when it changes its relative elevation above those adjoining it, or disappears to permit some other bench or ledge to form the actual comb of the mountain. Thus our journey offers a constant succession of new local pictures, the path we are tracking leading us from a smooth floor, clothed with soft herbage, to reefs and cliffs, and back again alternately,—sometimes to one verge of the mountain, to open one broad landscape to our view; sometimes to the opposite verge, to substitute another, and even wider picture; or again, along a high central crest, from whence we command both scenes, and can unite them into a perfect panorama.

Aspects of the Mountain Sides.—Mention has been already incidentally made of some of the prevailing features of the slopes of the Appalachian Ridges, their benched outline, faint on their dipward sides, conspicuous on their escarped ones, and their general vesture of forest, stunted and sparse towards the crests, but luxuriant and dense low down. It is now in place to speak concisely of one or two other features. Nearly all the higher ridges, particularly those of monoclinal structure, have their flanks thickly strewn with a stony rubbish, the wreck of the disrupted materials of the mountain, dislodged from the outcrops of its strata, and left dispersed in wild confusion from its very summit to its outer base in the valley below. This fragmentary matter, which is of all sizes, from sand and comminuted shale to vast angular blocks of the bulk occasionally of a small house, is coarsest and in greatest quantity where the strata which have supplied it are alternately massive and soft. It would appear to prevail in greatest plenty near and within the deep clefts or notches of the mountains through which the floods tore their violent passage, and along the beds of which the comparatively puny and quiet rivers now find their easy channels across the chain and towards the ocean. In such localities the covering of loose blocks of stone above the strata and the soil is so thick, the pieces are so large, the vast pile so steep and pervious to the rain, that neither tree nor shrub gets foot-hold, and, as a consequence, the mountain is utterly naked of foliage. These great "*stone-slides*," as they are called, face in some places the entire mountain from its summit to its base, but more commonly they occur in enormous patches. The sandstone blocks of which they consist are usually coated with a dark grey lichen—their surfaces being too dry for even a green moss—and this lichen, blackened by decay, imparts a singularly austere and savage aspect to the mountain-passes. We shall discuss in another place the question of their origin, and that of the period of their production.

Passes, or Notches in the Mountains.—Among the local scenes characteristic of the Appalachian Chain, none, perhaps, are so impressive and picturesque as the deep notches or defiles in the ridges. They are of two classes: indentations or clefts, which do not descend to the level of the adjoining valleys; and more profound gorges, intersecting the mountains to their very base. The former are called "Wind-gaps," from the almost constant presence of a breeze in one or other direction through them; and the latter—those at least which afford passage to the larger rivers—are called "Water-gaps." They are various in their forms, both as respects their profile and their ground-plan. In their simplest type, these notches are mere wide clefts, the sides of which slope at inclinations rarely exceeding 45°, until they reach the base of the mountain, where, in some cases, they approximate so closely as to leave space for only a narrow stream; in others, they are still so wide apart as to let the broadest rivers flow between them. Numerous deviations from this regular profile are to be met with, all of which are traceable to geological conditions in the dip and composition of the strata intersected. I have elsewhere—in the pages devoted to the discussion of the effects of local erosion upon strata—classified the several forms of our mountain-gaps, and explained the origin of the many curious modifications of shape which they exhibit. For the present we shall refrain from so close an analysis; and viewing them only as specimens of scenery, confine our attention to such features as give them distinctive pictorial characters. In this light they may be regarded as of two classes: 1st, Simple, straight, transverse notches, cut squarely or at a large angle across the ridges; 2d, Complex, or winding passes, often curving like a goose's neck. Those of the first class generally prevail where the intersected mountains, if monoclinal, possess but a single crest, or contain but one hard stratum, or where they are of anticlinal or synclinal structure. Those of the second class occur in those ridges which include two or more thick ribs of hard rock, separated by some easily-wasted soft material, and which, therefore, possess compound or double crests. The gaps in the Kittatinny Mountain, and those in most of the barrier ridges of the anthracite basins, are of the first description; while some of those cutting the monoclinal ridges of the great limestone valleys west of the Susquehanna, and also the ridges next exterior to the coal-fields, appertain to the second class, or possess the more picturesque winding outline.

The scenery connected with the simpler straight notches is rather tame, unless where the mountain is unusually lofty, and where its two ends, exposed to view in the gorge, are covered, in whole or part, with the dark "stone-slides" previously described, and then it sometimes possesses a degree of savage grandeur. There is, however, one form of the straight notch which is extremely impressive. It is when the mountain contains one great convex wave of some hard formation, which spans it from base to base, and exposes its own edges in the form of a majestic arch on each side of the gap in shattered mural precipices. Then, when the scene is large, the width and elevation of the rainbow-like curving cliff impresses the sense with something approaching the sublime. Pennsylvania possesses a number of these arch-enclosed passes, but

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PASS OF THE LEHIGH, AT MAUGH CHUNK

they are for the most part comparatively short and low. That in the Wills' Mountain in Maryland, near Cumberland, is larger; but the finest of all in the Appalachian Chain are to be seen in Virginia. We must go, however, to the Jura chain of Switzerland to behold these curious and impressive arch-formed mountain-notches in their highest picturesqueness and grandeur.

Among the class of simple notches, the Delaware Water-gap, or that by which the Delaware River passes through the Kittatinny Mountain, is one of the most interesting. The Lehigh Water-gap, being a simpler, straighter thorough-cut, is rather less impressive. It is, however, a good example of the class. (See the Plate.) One of the most interesting passes of this description is that of Jack's Mountain on the Juniata. The denuding waters shaping this gorge, have not only made a nearly straight thorough-cut in the mountain, which here contains two great anticlinal waves of the strata, but they have trenched the larger western wave so effectually in the longitudinal direction, as to have produced in it four terminal spurs descending into the pass—the four spurs resulting from two hard formations, divided into four outcrops by truncation at the top of the wave or arch, and a deep scooping down of the soft strata between and under them.

Of the wider river-passes, that in the Second Mountain at the Susquehanna is a fair specimen. The sketch given (see the Plate) shows the breadth of the river and the ribbed character of the mountain.

The winding passes of the Appalachian Chain usually lead us into the mountain, perpendicularly to its face, and then, gracefully deflecting, take us centrally along it, between its two high crests, a shorter or longer distance, perhaps even half a mile, and then, curving in the opposite direction, lead us out again into an open valley beyond. In this constantly-bending course we are presented with an ever-shifting variety of mountain-curve and perspective; a brawling river runs at our feet on one side, and the mountain presses close on the other, generally clothed with timber, and here and there showing some bold buttress of rock or high impending crag. The scene is invariably interesting; oftentimes it is extremely beautiful, so varied are the effects of light and shade; but it is seldom grand, neither its magnitude nor style of features permitting it to be sublime.

There is, perhaps, nowhere within the State, nor indeed within the Appalachian Chain, a more beautiful pass of this description than that through which the Lehigh River flows just below the town of Mauch Chunk. The annexed sketch of it from the north is taken from a point half-way up the Sharp Mountain above the town. (See Plate.) Bear Gap, north-west of Shamokin, is another good example of this class of river-passes. Both of these are through the same group of rocks, the Subcarboniferous or Vespertine sandstones, and they are therefore very similar in general outline. The picture of the Mauch Chunk notch exhibits the nearer rib of the mountain shaved down by the waters into a long-pointed spur standing across the opening, and behind it the further or south rib or crest lapping past it. The same structure is conspicuous in the Bear Gap. In some of these winding notches the inner spur is the lowest, in some the outer, and in others again they are of nearly equal elevation; and these, with variations in the length of the inner reach, are their chief modifications of form. The passage of the Susquehanna River through the Nanticoke Mountain, west of Wilkesbarre, is a winding gap on a smaller scale.

GENERAL CHARACTER OF THE SCENERY IN THE VALLEYS OF THE APPALACHIAN ZONE.

It is impossible to convey through written descriptions merely, to even the best-trained imaginations, any just conceptions of the scenery in detail of the plains and valleys of a region embracing so many features, and composed of so wide a diversity of geographical elements. All that I shall attempt, therefore, will be two or three general sketches of the kinds of landscape which characterise the different principal classes of our valleys.

Anticlinal Valleys.—A sufficiently full account has been given of the structure of the anticlinal valleys of the State, to suggest the general nature of their scenery. None of them present features of much picturesqueness, except on a petty scale where their streams are bordered by limestone cliffs, or pass the end of some truncated ridge. The narrower ones offer little to the eye, except the steep flanks of the sandstone mountains which confine them, or, it may be, one fine general picture as we gaze in the direction of their length. The wider ones, arched as they are in the middle, furnish many points of view, presenting rich backgrounds of receding mountains and pleasing middle distances of fertile champaign tracts, studded with farms and farmhouses, and here and there a forge or smelting-furnace.

Synclinal Valleys.—The scenery of the synclinal valleys of the chain is so various as almost to baffle description. Within the coal-basins it is made up of softly undulating curves, defining the slopes of the bounding mountains, and the succession of nearly parallel rolling hills which fill the spaces between them. These hills are tame in form, being usually straight, level, and evenly rounded at their ends. The most pleasing pictures in the Pottsville and other anthracite valleys are such as embrace views up or down the smaller transverse valleys of the lateral streams which intersect the basin, like those of Mill Creek, Silver Creek, or the West Branch of the Schuylkill. Some charming general views are procurable from the higher points within these basins—such, for instance, as that at the water-shed, or source of the Schuylkill east of Tuscarora, or that between the East and West Norwegian Creeks. In fact, wherever there is a high point—the saddle-shaped summit of a ridge in the centre of the basin, or a spur coming forward from one of the mountains enclosing it—we may hope, by ascending it, to get a view which will well repay us. Nevertheless, the first and second coal-fields contain but a small amount of scenery of that striking kind which is most acceptable to the landscape-painter.

The synclinal valleys and plains west of the Susquehanna are, on the whole, much more picturesque. They are bordered by the anticlinal mountains and their many spurs, and have often therefore varied and striking backgrounds. The beds of these valleys are so interspersed with hills and forest-tufted ridges, scolloped out extensively by the waters, and are so well sprinkled, for the most part, with clumps of wood amid the farms, as to furnish landscapes which, if they are not superb, are often really beautiful.

There are two or three synclinal belts so unlike the rest in their topographical features and scenery as to deserve a passing mention. I allude to the Muncy Hills on the south border of Lycoming County, and to the Frankstown Valley in Blair. These tracts are studded with short rounded hills, deeply carved and ravined, and when viewed from an elevation at a distance they look exceedingly like the wildly-tossed waves of the ocean, after the gale has shifted its direction, and raised what is called a "chopping sea." That portion of Frankstown Valley which is included within the Cove of the Lock Mountain exhibits this tossed surface in a remarkable degree. (See the Sketch.)

Monoclinal Valleys.—The long narrow valleys enclosed between the straight, parallel, sandstone ridges of the chain, are seldom attractive in their scenery. Their features are very monotonous; their surfaces are generally stony, or more or less covered with rubbish from the mountain-sides; and they are, therefore, usually under forest, and this contributes much to their general tameness of aspect. For the present, therefore, we shall not linger among them.

SCENERY CHARACTERISTIC OF THE BROAD VALLEYS OF COMPLEX STRUCTURE.

By far the most attractive scenery within the mountain-zone of the State is to be met with in the broad, cultivated valleys, watered by the great rivers or their principal tributaries. These embrace all the elements of picturesque beauty which the region possesses; forest-covered mountains, rolling hills, fertile spreading plains, and low verdant meadows—every combination of open, cultivated farm-land, lines and tufts of woodland, houses, villages, and streams; and their canals, aqueducts, viaducts, and bridges. The valleys and plains, intersected by and bordering the great Susquehanna and its two noble branches, those traversed by its beautiful feeder the Juniata, and those again watered by the Delaware and its great branch the Lehigh, are full of landscapes, blending the bold and the beautiful. Let the tourist place himself a little way off from one of these rivers, or from one of their larger affluents, upon some knoll, or the point of some elevated spur, choosing a spot unobstructed by trees, and he will usually see spread before him a truly noble picture. If it is a view lengthwise, up or down the valley, he will behold on either hand, ridges and mountains, with their knobs, buttresses, and crests piled in fine, long perspective behind and above each other, as far as his eye can reach; lower down and nearer, and more in the middle of the scene, his eye will rest on a broad, rolling surface, full of patches of woodland, and farm, and pasture; and again, looking deeper into the valley, he will see a succession of cultivated terraces, each bounded by a steep and ravined slope richly clothed with wood, until descending, step by step, to where the stream or river winds through the lowest plain, washing the base of a line of bluffs, or spreading broad by the borders of low and grassy meadows, he contemplates its blue or silvery surface, fringed with luxuriant foliage, gleaming out and disappearing as he brings it in its continually expanding glories almost to his feet. More than one such scene will the skilful searcher after the picturesque and beautiful meet with in the Wyoming and Lackawanna Valley, particularly between Pittston and Nanticoke. A remarkably fine one is to be found between Catawissa and Bloomsburg, looking up the valley of the North Branch. There is another visible from the top of the Blue Hill opposite Northumberland, near the junction of the two great affluents of the Susquehanna, where, by a little change of position, one may embrace two other fine pictures of almost unequalled beauty. The view from that station northward or up the valley of the West Branch, embracing the reaches of the river, its islands, and the luxuriant foliage of its banks and bordering low grounds, and all the boundless abundance of the broad cultivated slopes and swelling hills beyond, is, for an inland scene, one of almost matchless richness. To see it in its most attractive tints, one should behold it in the month of June, while the foliage is fresh, and at an hour when the sun is drooping low towards the north-west horizon. There are many particularly attractive combinations of river and mountain scenery higher up the valley of the West Branch of the Susquehanna. The sketch from Fair-View Inn offers a good example. (See the Plate.)

Very charming pictures of boldly carved hills, verdant slopes, flat meadows, and luxuriant foliage, with a mountain on the one hand and a beautiful broad river on the other, are to be found in the Valley of the Delaware, at sundry places between Milford and the Delaware Water-gap. There are few finer views of this class than some we have seen from Fox Hill, overlooking Cherry Valley. There is much beautiful scenery of this description in the prolongation of the same belt further west. An uncommonly attractive instance is a view looking up the Lehigh from the solitary Red Hill which stands fronting the opening of the Lehigh Water-gap, at half a mile north of it. In the region of the Juniata, the ridge behind Lewistown commands two very noble pictures, one looking eastward towards the "Long Narrows," and showing the Shade and Blue Mountains (see Sketch); the other looking south-westward up the valley of the river. A charming scene is from a hill behind Mifflintown. There is probably no river in all the great length of the Appalachian Chain—rich as it is in streams flowing through fine mountain and valley scenery—that, for its length, passes such a succession of beautiful landscapes as the winding Juniata.

OROGRAPHY AND SCENERY OF THE THIRD DISTRICT.

Proceeding next in order to the third natural division of the State, or that including all the country N.W. of the escarpment of the Alleghany Mountain—saving the plain watered by the North Branch of the Susquehanna in the one corner of the State, and the slope between the Alleghany River and Lake Erie in the other—we shall find, upon a careful examination, that it is a great and complex basin, edged with a more or less lofty and abrupt escarpment or steep sloping wall, and bounded S.E. by a low fosse-like valley, and on the N. by plains. It is, in fact, but the north-eastern extremity of a vast trough-shaped plain or table-land, which ranges hence to the interior of the State of Alabama, and which I have elsewhere designated as the Great Appalachian Coal-field, the longest and largest coal-basin on the globe. A glance at its topographical and geological features, as shown on the geological map, will make it apparent that the formations and the general level of the surface ascend gradually toward the north-east. This fact is the key to all its external scenery. The basin-structure is shown in the north-westward declension of the formations bordering the region on the south-east, and their opposite dip where they rise again to view in the country bordering Lake Erie; but the simplicity of this trough-like configuration is interrupted in two districts,—in the S.E. by three or four great waves of the strata, the chief of which form the swelling ridges of the Negro Mountain, Laurel Hill, and Chestnut Ridge; in the N.E. by the intrusion of five long coves or valleys of anticlinal form, protruding south-westward into the table-land, and dividing it into six long, synclinal mountain-spurs. We may, therefore, appropriately separate the whole region into three subordinate areas,—first, the belt ranging through Somerset, Fayette, Westmoreland, Cambria, and Indiana counties, an undulated mountain-zone; secondly, the belt ranging E. and W. between the North Branch and the Alleghany River, and embracing all the northern table-lands of the State; and thirdly, the area lying west of the former and south of the latter, and constituting the hydrographic valley of the Alleghany and Ohio Rivers southward of the Clarion, a country of lower levels and smoother surface than either of the others.

1. *South-Eastern Belt of the Bituminous Coal Region.*—The general topographical character of this large natural division of the district is quite simple, though the scenery is far from monotonous. It is a broad, rolling table-land, traversed nearly from end to end by three wide, parallel mountain-ridges, and deeply ploughed in every portion of its surface, both ridge and valley, into ravines and hollows. North of the termination of the Negro Mountain, the belt embraces essentially but two plains or main valleys, but south of that point the rising of the Negro Axis divides it into three. The inclination of the strata, and a prevailing absence of any very firmly cemented or hard beds among them, combine to exclude from this country those salient features which so characterise the Appalachian Zone to the east of it. The mountain-ridges, and even the lesser hills between them, have broad, roundish summits, and comparatively gentle slopes, except indeed in more immediate proximity to the numerous streams which intersect them, bordering which the hill-sides are very steep. Many portions of the belt, particularly the tracts sloping into the larger rivers, are excessively eroded, and, as a consequence, the bottoms of the lateral ravines are sharp and narrow, and the hill-sides embracing them abrupt and rough in their lower portions. Unlike many of the Appalachian hills, which set out with a gentle rise and increase in steepness, these, for the most part, start boldly upward, and round gently off as we climb towards their summits. This description applies chiefly to the hills within the synclinal basins between the main mountains, and to the buttresses at their base, but nowise to the profiles of those mountains themselves, which display in their cross sections those beautiful double curves, convex above, concave on both sides below, which we may call the bell-shape. The immediate slopes or river-hills confining the great streams of the region, the Conemaugh and its main branch, Stony Creek ; also the Loyalhanna and the Youghiogheny and their feeders, spring steeply upward from the valleys, and being richly clothed with woods which retain somewhat the grandeur of the primeval forest, give views up or down the deep and narrow valleys which are, in many instances, uncommonly grand for a scale of scenery which cannot strictly be called mountainous. At numerous points overlooking the Conemaugh and the Youghiogheny, we see these rapid mountain-streams far below us, working their obstructed way along the beds of their deep glens for miles before us, their high wood-covered hills jutting and receding in beautiful perspective. This is, indeed, the prevailing picture wherever, from the upland, we look into the larger water-courses excavated within the main valleys or synclinal plateaus. But a different scenery accompanies all the chief rivers of the district where they pass through the mountain-ridges. The map shows that all the principal streams—the Conemaugh and its feeders, the Blacklick and Loyalhanna, the Youghiogheny and its feeder, Castleman's River—flow through the Laurel Hill, Chestnut Ridge, and Negro Mountain, by deep sloping clefts or notches, which cut them to the base. These mountains consist each of a broad anticlinal wave of rather gentle flexure, of the alternately hard and soft formations next beneath the coal strata. Each chief pass or water-gap is an oval amphitheatre, formed by two steep crescent-shaped mountain-slopes meeting below, in a nearly straight and narrow ravine, through the centre of which the river flows, brawling over a rocky and obstructed channel. There is a certain simple grandeur in these scenes, especially where the intersected ends of the mountain or sides of the gap are extensively sheeted with naked stone-slides of huge, grey, angular blocks, without verdure, which is not possessed by the steeper passes of the Appalachian Chain to the eastward. The finest views by far, are to be had when we stand on or near the summit of the mountain, and look midway into the notch ; we

may then usually combine with the wild foreground before us lateral peeps of the distant country through the ends of the gap, serving by their softness to enhance the ruggedness of the gorge or gulf in front. Some of the more rocky spots within these gaps, or bordering the streams in the country exterior to them, are pleasing and striking pieces of local scenery. Such, for example, are the Ohiopyle Falls of the Youghiogheny, and the scene near the Conemaugh Viaduct above Johnstown.

But the views characteristic of this region which most impress and charm us, are those to be met with when we climb to the higher summits of the mountain-ridges, and find favourable stations for gazing broadly into the country they overlook. The widest and richest of these mountain-views are those which are commanded by the eastern brow of the Alleghany Mountain, when we look off from almost any of its numerous boldly-jutting buttresses. These views embrace, to be sure, the Appalachian Zone proper, and not the belt of country we have last been describing; but they are too characteristic of the position of the eastern edge of the great western plateau or basin, and of its dominant elevation, to be passed by, in this account of the physical aspect and scenery of the State. Mention was made in previous pages of the scenes visible from the highest central crests within the Appalachian ridges, when we gaze across the chain, and see crest rising behind crest, like stupendous billows in some mighty sea ; but from the still loftier positions afforded by the brow of the Alleghany table-land, we look over this billowy ocean of mountains to much vaster distances, and the pictures are proportionately more superb.

Some interesting broad views are afforded by elevated positions high on either slope, or on the summit of the Laurel Hill, especially when our station gives us a sight westward through some broad notch in Chestnut Ridge, or over its summit, into the extended, cultivated, level country beyond. A fine wide scene of this kind may be had from Clifford's Tavern on Laurel Hill, looking over the Loyalhanna Gap, and another very striking one—an outline sketch of which is here presented—from the so-called Mud Turnpike looking westward. A most pleasing series of views may be procured by any one who ascends to the naked points on the western brow of Chestnut Ridge. With frequently beautiful foregrounds in the limestone and standstone rocks, forming the notched summit of the mountain, he gets a glorious expansive landscape wherever he gazes to the west or north into the broad plain or basin of the Ohio. He beholds a rolling surface, cut into innumerable softly-swelling hills, and intersected by scores of bright streams, covered with farms, farmhouses, and villages, shining brightly amid parks of wood and tufts of trees crowning the knolls, all stretching away to a seemingly illimitable distance till the plain meets the horizon. The ampleness of this field of view reminds him that he is standing on one of the westernmost outposts of the great Atlantic Chain, and that before him there rises no mountain-ridge of even the humble relative altitude of that beneath him in all the vast central plain of the continent till it nears the base of the Rocky Mountains.

2. *Northern Belt of the Bituminous Coal-field.*—The large tract composing the north-eastern termination, or northern border, of the great Bituminous or Appalachian Coal-field, is sufficiently well defined along its northern boundary by the lower plains or valleys of Bradford, Tioga, and Potter counties, which penetrate between its spurs, and by the margin of the lake-slope in Warren, Crawford, and Mercer ; but it has no very clearly-marked southern limit in any physical features, passing vaguely into the south-eastern belt in Clearfield, and into the basin of the Alleghany River in Jefferson, Clarion, Butler, and Lawrence. The entire tract is a table-

land, which rises gradually westward from the North Branch of the Susquehanna to the main water-shed in Potter and M'Kean counties, and declines again as gradually to the Alleghany River. Its mean elevation above the sea is about 1800 feet, though a few of its summits, especially near the water-shed and along the Alleghany Mountain, may be a little higher.

The eastern half of this northern plateau sends forward towards the N.E. five long parallel projecting spurs, each having the structure of an elevated flat basin, bounded on both sides, and at its rounded extremity, by a steep slope, descending into an external valley. These five spurs are so many partially-insulated coal-basins, the extremities, merely, of the long parallel belts of the coal-measures, which, further towards the S.W., merge together and deepen into the Great Bituminous Coal-field of the State. They are the result of five anticlinal waves of the strata, entering the region from the N.E., and expiring within the coal-field. In consequence of this south-westward subsidence of the waves of elevation of the crust, the whole of this portion of the belt displays a slight declension of level towards the south, as the drainage of the district plainly manifests. A glance at this portion of the geological map discloses the curious fact that every one of these five mountain-spurs, in which the Great Coal-field terminates, is cut to its base by one or more cross valleys or ravines, through which the existing large tributaries of the West Branch of the Susquehanna, the Loyalsock, Lycoming, and Pine creeks flow southward through them. While the general surface of the main table-land and its spurs is comparatively level, these ravines, by which it is intersected, are very deep, the hill-slopes, bordering Pine Creek and the West Branch and their feeders, being many hundred feet in height, and extremely steep. Advancing from S.E. to N.W. across these spurs, they grow relatively less elevated above their intervening valleys, the table-lands themselves remaining nearly at a constant altitude, but the levels of the valleys rising; and this gradation continues to the high plain or valley separating the fifth spur from the sixth or last in Potter County, where the lower grounds, penetrating the table-land, are at a greater altitude than anywhere else—this district being, in fact, the common centre of drainage of four extensive rivers, the waters of the North Branch flowing eastward, those of the West Branch southward, those of the Alleghany westward, and those of the Genesee towards the north.

The western portion of the northern table-land is but the north-eastern prolongation of the north-western margin of the Great Coal-field of the Alleghany and the Ohio rivers lifted gradually in level to a maximum elevation in M'Kean County of about 2000 feet. It is highest on its eastern side or towards the primary water-shed of the State, the mean level of the surface there exceeding that of the north-western border near the Alleghany River by 300 or 400 feet. This whole tract, constituted of the fifth and sixth sub-basins of the coal-field, gradually subsides in level towards the S.W., as is plainly indicated by the direction of the drainage of the Clarion and Alleghany, and their tributary streams. The strata decline in the same direction, but at a somewhat faster rate than the surface does, and hence the south-western portions of the tract contain a greater thickness of coal-measures than the north-eastern; indeed, in Potter, M'Kean, Warren, and the northern parts of Elk and Forest Counties, large tracts of the table-land are entirely naked of the coal-productive parts of the formation, being overspread by the conglomerate and other still lower formations known to underlie any workable coal-beds. The largest streams of the north-western border of this part of the plateau penetrate it from the north, as the feeders of the Susquehanna cut through the eastern district of the same belt. It is only in Potter and

M'Kean counties that the south-flowing rivers have their water-shed within the State. Elsewhere, to the E. and W., they ascend into New York. Hence it is that the valleys of the Alleghany River and of the North Branch of the Susquehanna are destined to become extremely important avenues of communication between the Coal-fields of Pennsylvania and the populous plains of her neighbouring sister State.

3. *Basin of the Alleghany and Ohio Rivers.*—After the general description of the aspect of this region as it is seen from the summit of Chestnut Ridge, little need be said in this preliminary physical sketch touching its structure and scenery. Broadly viewed, it is an extensive plain, or rather a very wide trough, falling gently in level from its two sides—the base of Chestnut Ridge on the S.E. and the water-shed of the lake streams on the N.W.—and declining still more gradually south-westward in the direction of its general drainage. Its surface is, however, greatly eroded or trenched by converging valleys and ravines, which break it up into a multitude of branching little plateaus and isolated conical hills. The beds of the deeper water-courses are usually from 200 to 400 feet below the general level of the upland, and this inequality of levels, and a prevailing convexity in the outlines of the hills, impart much boldness and variety to the local scenery. The rocks of the region are all horizontally stratified, and are of a somewhat incohering texture, the least easily excavated being soft freestones and limestones, while many of the beds are friable shales and marls of still less solidity. These geological conditions have permitted the waters, which originally wasted the whole tract, to shape its surface into every degree of slope, from the steepness of nearly vertical cliffs to the softest and gentlest curves conceivable. The denuding waters seem to have flowed across the district in a broad and ponderous sheet, cutting first great confluent troughs and valleys, and then, when checked, flowing off with a diffused and subsiding drainage, carving and sculpturing its rudely-moulded slopes into every degree of softer contour, until the last and lightest lines impressed upon it are indescribably fine and delicate.

As specimens of the more characteristic scenery of the region, I have introduced into this work a sketch of the country round Canonsburg in Washington County. The reader will derive a correct notion of the river-hills of the district, and of the aspects of the larger rivers, from the picture of Pittsburg and its environs.

OROGRAPHY AND SCENERY OF THE FOURTH DISTRICT.

The fourth physically-distinct district of the State, or that embracing Wayne, Susquehanna, Bradford, and part of Tioga counties, and watered by tributaries of the North Branch of the Susquehanna, is a country of such simple structure, that only a brief general description of it need be here presented. The surface is that of a rather roughly-undulated or hilly plain. Its eastern half, or that lying in Susquehanna and Bradford counties, is more broken and hilly than the parts west of the Susquehanna—a circumstance partly attributable to a difference in their geological composition ; the country east of the Susquehanna consisting largely of hard, micaceous, flaggy sandstones ; that west of the river, of a larger relative proportion of argillaceous sandstones and clay-shales. The whole surface is deeply trenched into slender valleys and ravines, some of the chief of which are thorough-cuts, passing from the East Branch of the Susquehanna, and from the Tioga River southward to the North and West Branches. Two or three of these continuous


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CANONSBURG, WASH^{G} COUNTY, P^{A}

valleys having very low water-sheds, constitute admirable thoroughfares for the commerce and intercourse of Pennsylvania with New York. The southern and western border of the tract has a deeply indented margin connected with the feature already adverted to, the existence, namely, of long, slender anticlinal valleys, carved out of its softer strata, penetrating south-westward between the high finger-shaped plateaus terminating the bituminous coal region.

This district is not without its fair share of striking scenery. Some of the views within the valleys of its chief rivers, the Delaware and Susquehanna, are grand and picturesque, particularly those visible from certain points on the edges of the table-lands overlooking those streams; and the same may be said of the valleys of their larger tributaries. Indeed, few of the Appalachian rivers can boast a greater amount of attractive valley-scenery than the North Branch presents throughout its whole course, from the great bend near the State line through New York, and thence through Pennsylvania to the Wyoming Valley. It owes this eminence, in part, to the beautiful manner in which its terraces of northern drift or gravel have been strewn and shaped at the last retreat or rush of waters across the continent.

A sketch, elsewhere introduced, of Spanish Hill, near Athens, in Tioga County, will convey some notion of the style of the hills, and of the remnant terraces of drift skirting their base.

Lakes.—It is a curious fact that nearly all the lakes and natural ponds within the State, excepting those of a similarly constituted district between the Alleghany River and Lake Erie, are embraced within the country contained between the Delaware River on the one side, and the Lehigh and the North Branch of the Susquehanna, or, more correctly, the lower part of the West Branch, on the other. This circumstance in their distribution is the more remarkable, when we reflect on their almost total absence from every part of the Atlantic slope between the Hudson and Georgia, and from every portion of the Appalachian Chain, notwithstanding its numerous valleys, S. W. of the Susquehanna. This deficiency, which is painfully felt by every tourist in search of the picturesque, extends also to the whole of the western slope of the Ohio-Mississippi Basin, and is a distinctive feature of the drainage of the whole country south of 41° of latitude. In contrast with so wide and complete an exemption from this beautiful feature, there is an unusual profusion of ponds and lakes throughout the greater part of the country lying north of the above-named boundary. What can be the cause of so singular a difference in the conditions of the flowing off of the waters? Simply the absence from the southern half of the continent of the great superficial stratum of gravel, sand, and clay, called by some geologists Diluvium, by others Drift, and by others, again, the Glacial Deposit. North-eastern and North-western Pennsylvania are just within the southern border of this great drift-formation, which extends indefinitely northward, even to the shores of Hudson and Baffin Bays, and of the Arctic Sea.

The broad, high table-land, in which the Appalachian Bituminous Coal-field terminates on the confines of New York, has evidently stopped the southward course of the nearly-spent sheets of water which transported the drift, and turned them south-eastward and south-westward over the two northern corners of Pennsylvania. A careful investigation of the distribution of the boulder-matter has shown me, that whereas it has scarcely reached the high primary water-shed of Potter and M'Kean counties, to enter the valleys of the Sinnemahoning or the other northern streams of the West Branch, it has been strewn much more freely over Bradford, Susquehanna, and Wayne counties on the east, and Warren, Crawford, and Elk on the west. In both of these districts the drift, as we shall see hereafter, thins down to a sheet of gravel, so shallow and sparse as scarcely to be discernible on the table-lands of Monroe and Lucerne, and of Butler and Lawrence. But while this is so, it is traceable much further south, in both these quarters, along the immediate river-valleys which extend from the plains of New York into or through the Appalachian Plateau. Though we discern the last or most southern sprinkling of it on the upland, no further south in the Appalachian Valley than Northampton and Lehigh counties, it is packed in a thick sheet, carved here and there into bold terraces, all the way down the valley of the Delaware to the level of the tide-water. And again in Western Pennsylvania, while it ceases on the hills in Mercer and Butler counties, it follows all the valleys which enter the Ohio River from the north, not only those of the Alleghany and the Beaver rivers, but many more, debouching much further south in the State of Ohio.

The prevalence of lakes and ponds within the drift-covered tracts of the country would appear to be connected with the partial blocking-up of the valleys and ravines by this material choking the outlets of the waters. It may be partly due, also, to the extreme levelness which it has imparted to the surface; the original inequalities of the rocky floor of the country having been smoothed by the filling-up of the lesser depressions with this loose superficial coating. It has thus produced wide level plains in localities where, but for its presence, continuous irregular slopes would exist to drain away the waters in slender streams. In districts not covered with drift the water-sheds or summits separating the different systems of ravines and valleys are almost invariably too narrow to contain any large collections of water, as the opposite slopes are in close proximity. This is particularly true where the strata are anticlinal, or dip opposite ways from the summit, or even where they are monoclinal, or dip all in one direction. But in regions where the foundation-rocks of the country are overspread with a smooth mantle of drift, these water-sheds are apt to be extremely level plains, into which the lateral brooks descending from the hills collect and produce small lakes. Certain it is, that the most lake-bestudded districts of the United States and British territories of the continent are just those where these two conditions, namely, wide flat water-sheds and deep coverings of drift, prevail together. The Lacustrine tracts at the sources of the northern feeders of the St Lawrence and its Upper Lakes, but especially those at the sources of the Mississippi, where it interlocks with the waters of the St Lawrence and with those of Hudson Bay, are striking exemplifications of this general law.

Other circumstances, however, besides the existence of the drift-stratum, conduce to the prevalence of lakes in the country N., N.E., and N.W. of Central Pennsylvania. From the Susquehanna River south-westward, the strata of the Appalachian Chain and the Atlantic Slope are scarcely anywhere basin-shaped, or even flat in their dips over large areas; but they undulate and incline at high angles. As a consequence, the ground above them slants in one or other direction too rapidly to support large tracts of still-water. But N.E. and N. of the Anthracite Coal-fields, and throughout Middle and Western New York, they incline very gently, and permit a far more frequent occurrence of horizontal plains or nearly level valleys, whose beds have been further smoothed by the introduction of the drift. The large lakes of Central New York evidently owe their origin to long transverse trenches or valleys, scooped out of the gently-south-dipping strata of that district, by the powerful force of a heavy sheet of moving water passing over the terraced surface of the State in a direction transverse to the outcrops of the rocks, or from N. to S. The softer formations have been excavated into long wide ravines, or great shallow valleys; while the harder ones have been left at higher levels on the edges of the great terraces, contracting and partially closing the northern ends of these vast ravines. It is to the flattish southward dip of the strata, their alternation of hard and soft, and the transverse rush of the eroding currents, that we must ascribe the production of the basins of these beautiful sheets of water.

OROGRAPHY AND SCENERY OF THE FIFTH DISTRICT.

After the descriptions already given of the other portions of Northern Pennsylvania, it is not necessary to dwell long upon the physical structure and aspect of that natural area which lies between the northern escarpments of the Lower Coal-rocks in Warren, Crawford, and Mercer, and the shore of Lake Erie. This is a somewhat diversified, undulated district, full of moderately deep ravines, intersecting and insulating innumerable low hills, which grow flatter and tamer as we approach the water-shed, which traverses the belt longitudinally in a meandering course from New York to Ohio, at an average distance of 10 or 15 miles from the lake-shore. Between this water-shed or flat summit, dividing the streams flowing towards the Ohio River from those entering Lake Erie, and the edge of the table-shaped hills, containing the lowest coal-rocks, the general surface, disregarding the local hills and hollows, is approximately a level plain. It is overstrewn with a thin sheet of drift, which is accumulated, however, in thicker masses, in terraces within its deeper valleys. This plain has a mean elevation above the sea of somewhere between 1100 and 1200 feet. Owing to a combination of geological conditions already mentioned, namely, a flat dip in the strata and a surface-covering of gravel or boulder-drift, it possesses several lakes near the sources of its streams. The largest of these is Chatauque Lake, in New York, the surface of which is 1272 feet above tide-water. The chief lakes in Erie and Crawford counties are Oil-Creek Lake, Lake Pleasant, Lebœuf or Waterford Lake, Conneautte Lake, and Conneaut Lake. To these might be added Pymatuning Swamp, a long tract of wet, peaty marsh, covering the water-shed between Crooked Creek and an eastern tributary of Chenango Creek.

The other much narrower division of the district—or that which lies between the water-shed of the Ohio and Lake streams and the shore of Lake Erie—has a somewhat different configuration of its surface. It descends rather rapidly from the water-shed to the lake by a succession of obscure, alternately gentle and steepish slopes. The declination of the ground may be inferred from the difference in the elevation of its two margins; that of the water-shed, in which it begins, being nearly 1200 feet, and that of the lake, in which it ends, being only 565 feet above the level of the sea. This tract is cut transversely by numerous sharp ravines and long tortuous valleys, carrying its waters to the lake; and the borders of some of these afford many small, pleasing bits of scenery. But the characteristic, and altogether the most impressive pictures, are those of the lake itself. The first view which the traveller gets of this broad inland sea as he passes the water-shed, especially when the surface of the lake, crisped into gentle waves by a light western breeze, reflects the deep blue of the upper sky, never fails to charm and surprise him.

HYDROGRAPHY.

Turning our attention from the Orography of Pennsylvania, or the relief of its surface, to the Hydrography, or the features of its drainage, we perceive it to consist of three principal slopes, divided by two chief water-sheds—the Primary Appalachian Water-shed already traced, dividing the Atlantic streams from those of the Ohio River, and the Lacustrine Water-shed, separating the latter from the tributaries of Lake Ontario and Lake Erie.

The Great Hydrographic divisions and sub-divisions of the State may be appropriately classified in tabular form in the following manner :—

Atlantic drainage flows into	Basin of the Delaware Bay, which consists of the	Basin of the Delaware River. " Schuylkill " " Brandywine " and a few other small streams.
	Basin of the Chesapeake Bay, which embraces	Basin of the Susquehanna. " Potomac,—part only of which lies within the State.
Mexican Gulf drainage flows into	Basin of the Ohio River, which includes in Pennsylvania	Basin of the Alleghany River. " Beaver " " Monongahela " and numerous lesser streams entering the Ohio River.
Lake drainage flows into	Basin of Lake Ontario in Pennsylvania, which embraces	Basin of the Genesee River at its source.
	Basin of Lake Erie, embracing	Conneaut Creek, and numerous short streams.

ATLANTIC DRAINAGE.

Its general Periphery.—The Atlantic drainage of the State comprises about 28,526 square miles of its surface. The water-shed, enclosing the streams descending towards the Delaware and Chesapeake Bays, traced in its entire sweep round the sources of the Delaware and Susquehanna in New York, is an irregular elliptical girdle ; it begins near the mouth of the Delaware Bay in New Jersey, ranges northward through that State to near its northern corner, thence northward into the Catskill Mountain, dividing the drainage of the Delaware from that of the Hudson and of the Mohawk, and thence north-westward along the Helderberg Mountain, between the streams of the Mohawk and those of the Susquehanna. Becoming now the primary water-shed, it turns to take a tortuous course south-westward between the waters of the North Branch of Susquehanna and those of Lake Ontario, until in Potter County, Pennsylvania, it begins to divide those of the West Branch of Susquehanna from those of the Ohio River, and continues thus southward to Cambria County, where it becomes the crest of the Alleghany Mountain, and separates the sources of the Juniata branch of the Susquehanna, from those of the Conemaugh of the Ohio Basin. Near the Maryland line, and in Maryland, this water-shed divides the head-streams of the Potomac from those of the Youghiogheny, another western water.

Its chief River Basins and their dividing Water-sheds.—The waters of the Atlantic drainage in Pennsylvania, belonging to the three large river-basins of the Delaware, Susquehanna, and Potomac, are separated into these receptacles by two important water-sheds, extending from the tide-water to the primary water-shed of the Appalachian Chain, or transversely to the mountains. That which insulates the streams of the Delaware, commences below Trenton, and extending north-westward through Bucks, Lehigh, and Schuylkill counties to the sources of the Catawissa, there deflects northward through Lucerne, round the sources of the Lehigh, and thence through Wayne County, between the Delaware and the Susquehanna waters into New York.

The other, which divides the waters of the Susquehanna from those of the Potomac and other streams entering the Chesapeake Bay, commences near Havre-de-Grace in Maryland, enters Pennsylvania in the western corner of York County, runs thence north-westward to the Kittatinny Mountain in Franklin, and pursues an exceedingly tortuous course among the crests of the Appalachian Ridges, through Franklin, Perry, Juniata, Huntingdon, Fulton, and Bedford counties, to a point where it meets the great primary water-shed of the State in the crest of the Alleghany, in the south-eastern corner of Somerset County. This is the southern boundary or rim of the Susquehanna Basin; its eastern boundary ranges from the head of the Chesapeake Bay northward through Chester, Berks, and Schuylkill counties to the sources of the Catawissa, where it falls into the water-shed confining the Delaware Basin. Between it and the lower part of the Delaware water-shed lies the basin of the Schuylkill River, and also that of the Brandywine, with one or two smaller ones, tributary to the Delaware and Chesapeake bays.

Areas of the Chief River Basins.—The portion of the hydrographic basin of the Delaware River, lying within the State, contains about 3895 square miles of surface. It is a long comparatively narrow strip of country, widest in the middle, and stretches across the whole Mountain-zone of the State, from New York to the head of tide-water.

The large division of the Susquehanna Basin belonging to Pennsylvania covers an area of not less than 17,018 square miles. It is much the largest of all the primary hydrographic basins of the State.

The area of the Schuylkill Basin, carefully estimated, contains about 1884 square miles. This, which may be regarded as only a secondary basin of the Delaware River, extends from the tide-water into the mountains, but not across them, and does not span quite one-half of the breadth of the State.

That part of the Potomac Basin which extends into Pennsylvania, occupying portions of Adams, Franklin, Fulton, Bedford, and Somerset counties, has a surface of about 1581 square miles.

The small remaining area, tributary to the Atlantic tide-water, is the triangular basin of the Brandywine and its adjoining streams in Delaware and Chester counties. This we may estimate to cover not more than 720 square miles.

The several chief river-basins of the Atlantic system here sketched, are in close hydrographic contact both with each other and with the exterior river-basins of the country. Their bounding and dividing water-sheds are in many places so depressed as to afford, especially in the valleys which they traverse, the most facile communication across them. One is astonished, indeed, to find by how many low summits, easily traversable by railroad and canal, they are connected with each other. Thus, however important a knowledge of these water-sheds or summit-lines of the drainage of the country is to the civil engineer in planning or constructing canals and other highways, they constitute no serious obstacle to free communication in all directions. They no doubt deflect the currents of inland trade, but it is only in a few districts that they can be said to arrest them. It is a fortunate feature in the Atlantic River Basins of Pennsylvania that they are thus connected, by wide frontiers and through singularly flat summits, with the two other great river-systems of the country, the Lake Basins in the north, and the great receptacle of the Ohio drainage in the West. Thus Pennsylvania, though traversed nearly from end to end by a broad zone of mountains, is in no way cut asunder by it. On the contrary, its river-valleys rather link its distant parts together, and by their stretching beyond its borders into the neighbouring States, open channels to a wide external commerce.

Mexican Gulf, or Ohio River Drainage.—The large river-basin of the Ohio-Alleghany River, comprising all that district which lies west of the Primary Water-shed of the State, excepting merely the narrow strip composing the Lake Erie slope, contains, upon a careful estimate, about 12,632 square miles of surface. From a mean elevation above the sea in its north-eastern and south-eastern corners of about 1800 feet, it falls towards the Ohio River to a level of about 1000 feet, and in the beds of the streams to about 700 feet. This river-basin has on its N.E. that of the Genesee, and on its E. those of the Susquehanna, the Juniata, and the Potomac. On its N.W. it is separated by a very easily passed water-shed from the Basin of Lake Erie.

The Basin of the Juniata River, by far the largest tributary of the main Susquehanna below its two northern branches, covers a surface of about 3428 square miles. By this basin and that of the West Branch, the Susquehanna River expands itself entirely across the mountains, spreading to a far greater distance westward than it does eastward. The North Branch, however, which must be regarded as the main stream—the others being affluents—has its area of greatest expansion towards the north, where in New York it waters a wide extent of country.

The Pennsylvanian portion of the basin of the Ohio River is divisible into three sub-basins of drainage—that of the Alleghany River, that of the Monongahela, and that of the Beaver River. The hydrographic valley of the Alleghany River within Pennsylvania occupies an area of about 9546 square miles. The portion of the Monongahela Basin included within our borders covers the less space of 2800 square miles. The district, drained by streams entering the Ohio directly, including that part of the Beaver River Valley which belongs to our territory, may be assumed to contain about 3086 square miles.

The Lake Drainage.—A very small area of the Genesee Basin of Lake Ontario enters Pennsylvania ; it probably contains not more than 90 square miles.

The Lake Erie Slope, occupying a part of Erie and a small portion of Crawford counties, may be estimated to cover about 352 square miles. It is very difficult, in the absence of a perfect map of the streams of Pennsylvania, to reach exactitude in the estimation of the areas occupied by these several river-systems and their subdivisions.

THE DELAWARE

THE DELAWARE

- Has its *source* in the N.E. corner of Delaware County, at an elevation of about 2000 feet above the sea.
- It *traverses* Delaware County, New York, flows between Pennsylvania and New York as far as Carpenter's Point, thence between Pennsylvania and New Jersey as far as the State-line below Chester, and thence between the State of Delaware and New Jersey to its estuary the Delaware Bay.
- It *receives*
  - from the *right*
    - the Lackawanna Creek,
      - which *rises* in Moosick Mountain, on the Eastern borders of Wayne County, and flows Eastward through Wayne and Pike.
      - The *towns* washed by it and its branches are—Belmont, Mount Pleasant, Bethany, Honesdale, and Hawley.
      - It *empties* into the Delaware between Mount Hope and Barryville.
    - the Lehigh River,
      - which *rises* in the table-land of the Pokono Mountains, in the swamps called the "Shades of Death," in Monroe and Lucerne counties.
      - It *traverses* thence between Lucerne and Carbon, and across the latter, and between Lehigh and Northampton, and through the latter.
      - The *towns* seated on or near it and its branches are — Stoddartsville, Whitehaven, Pennhaven, *Mauch Chunk*, Lehighton, Weissport, Parryville, Allentown, Bethlehem, and Easton.
      - It *empties* into the Delaware just below Easton.
    - the Schuylkill River,
      - which *rises* in the Southern Anthracite Coal-field in Schuylkill County.
      - It *traverses* Schuylkill, Berks, Montgomery, and Philadelphia counties, flowing towards the S.E.
      - The *towns* seated on or near it are—Tuscarora, Middleport, Port Carbon, Pottsville, Schuylkill Haven, Orwigsburg, Port-Clinton, Hamburg, Reading, Pottstown, Phœnixville, Norristown, Manayunk, and Philadelphia.
      - It *receives*
        - on the *right* from Broad Mountain—Mill Creek, West Branch, Tulpehocken, and French Cr.
        - on the *left* from Broad Mountain—Little Schuylkill, Maiden Cr., Manatawny, Perkiomen, and Wissahickon;
      - and *empties* into the tidal portion of the Delaware a few miles below Philadelphia.
  - from the *left*
    - the Pawpacton,
      - which *rises* in the plateau of the Catskill Mountain;
      - *traverses* Delaware County, N. York, flowing westward;
      - and *empties* into the Delaware at Hancock.
    - the Neversink River,
      - which *rises* in the North part of Ulster County;
      - *traverses* Ulster and Sullivan, flowing southward.
      - The chief *town* seated on or near it is Montecello.
      - It *empties* into the Delaware at Carpenter's Point, below Port Jarvis.
    - several large streams in New Jersey, the chief of which is the Rancocos,
      - which *rises* in Monmouth and Burlington counties, New Jersey;
      - and *traverses* Burlington County.
      - Its *towns* are—Pemberton, Mount Holley, Vincent-town, Eayrstown, Lumberton, &c.
      - It *empties* into the Delaware a few miles below Burlington City.
- It *passes* by or near the *towns* of Narrowsburg and Port Jarvis in New York; Milford in Pennsylvania; Belvidere in New Jersey; Easton and New Hope in Pennsylvania; Trenton, Bordentown, and Burlington in New Jersey; Philadelphia and Chester in Pennsylvania; and Wilmington in Delaware.
- It *empties* into the Delaware Bay.

THE SUSQUEHANNA

- *Rises* in Otsego County, New York, in and near Otsego Lake, on an elevated table-land.
- It *traverses* Otsego, Broome, and Tioga counties, in New York, and entering Pennsylvania in Bradford County, passes through it and Wyoming, Luzerne, Columbia, Montour, and Northumberland, and flows between the last and Snyder, and between Dauphin and Perry, and Cumberland, and thence between Lancaster and York to Maryland, where it presently enters the head of the Chesapeake Bay.
- It *receives*
  - from the *right*,
    - the Shenango River,
      - which *rises* in Madison County, New York;
      - *traverses* Shenango and Broome counties, N. Y.;
      - *washes* the towns of Sherburne and Norwich;
      - and *empties* into the Susquehanna at Binghampton in N. Y.
    - the Chemung River,
      - which *rises* in Steuben County, N. Y.;
      - *traverses* Steuben and Chemung counties, N. Y.;
      - *washes* the towns of Bath and Elmira;
      - and *empties* into Susq., below Athens.
    - the Great West Branch of the Susquehanna, its rival in size,
      - which *rises* in Cambria County, Pennsylvania;
      - *traverses* Clearfield, Clinton, and Lycoming, and divides Union from part of Northumberland to its junction with the North Branch of the Main Susq.;
      - *washes* the towns of Clearfield, Lockport, Jesseyshore, Williamsport, Muncy, Milton, Lewisburg, and Northumberland;
      - and *empties* into the Susq. at Northumberland;
      - It *receives*
        - from the *right* — Clearfield Cr., Mushannon Cr., Bald Eagle Cr., Whitedeer-hole Cr., Buffalo Cr., and several lesser ones;
        - from the *left*—the Sinnemahoning Cr., Kettle Cr., Pine Cr., Lycoming Cr., Loyalsock Cr., Muncy Cr., Chillisquaque Cr., and several lesser ones.
    - the Juniata River,
      - which *rises* on the Eastern slope of the Alleghany Mountain in Blair and Bedford counties;
      - *traverses* Bedford, Huntingdon, Mifflin, Juniata, and Perry counties;
      - *passes* the towns of Bedford, Huntingdon, Newton Hamilton, Lewistown, Mifflintown, and Millerstown;
      - and *empties* into the Susq. at Duncan's Island, above Petersburg;
      - It *receives*
        - from the *right* — Trough Cr., Aughwick Cr., Tuscarora Cr., Buffalo Cr., and several lesser ones;
        - from the *left* — Frankstown Cr., Kishicoquillas Cr., Cocolamus Cr., and several lesser ones.
    - also numerous second-rate, but important streams,
      - such as Cayuga River, Sugar Cr., Tawanda Cr., Mahoopeny Cr., Fishing Cr., Penn's Cr., Sherman's Cr., Conedogwinit Cr., Yellow Breeches Cr., Conewago Cr., Codorus Cr., and Deer Cr.
  - from the *left*,
    - the Lackawanna Creek,
      - which *rises* on the border of Wayne and Susquehanna counties;
      - *traverses* part of Susquehanna and Luzerne Counties;
      - *passes* by Carbondale, Scranton, and Pittston;
      - and *empties* into the Susq. at Pittston.
    - the Swatara Creek,
      - which *rises* in Schuylkill County in the Southern Coal Basin;
      - *traverses* the Western part of Schuylkill, also Lebanon and Dauphin counties;
      - *passes* the towns of Tremont, Pinegrove, and Humel's Town;
      - and *empties* into the Susq. at Middletown.
    - the Connestoga Creek,
      - which *rises* in the Southern corner of Berks County, on the border of Chester;
      - *traverses* Lancaster County;
      - *passes* Morgantown, Churchtown, Lancaster, and Safe Harbour;
      - and *empties* into the Susq., near Safe Harbour.
    - and Octorara Creek,
      - which *rises* near the Eastern side of Lancaster County, South of the Copper Mine Ridge;
      - *traverses* the Southern part of Lancaster County, and a small part of Cecil County, Maryland;
      - and *empties* into the Susq. a few miles above Port Deposit.
    - besides many smaller ones,
      - such as the Wyalusing Cr., Tunkhannock Cr., Nescopeck Cr., Catawissa Cr., Shamokin Cr., Mahanoy Cr., Mahantanga Cr., Wiconisco Cr., Chiques Cr., and Conewingo Cr.
- It *passes* by or near the towns of Unadilla, Great Bend, Binghampton, Owego, Athens, Tawanda, Tunkhannock, Pittston, Wilkesbarre, Berwick, Bloomsburg, Danville, Northumberland, Sunbury, Dauphin, Harrisburg, Marietta, Columbia, Port Deposit, and Havre-de-Grace.
- It *empties* into the Chesapeake Bay in Maryland, about 12 miles South of the State line of Pennsylvania.

THE POTOMAC

Rises in Hardy County, Virginia, at an elevation of about 2500 feet above the sea.

It *traverses* Hardy County, Virginia, and Alleghany County, Maryland, and flows thence Eastward and South-eastward, between Maryland and Virginia, the whole way to its entrance into Chesapeake Bay.

It *receives*

- from the *right*: several rivers and important second-class streams, which, belonging wholly to Virginia, need not be here described.
- from the *left*: no important river, but several large streams, called "Creeks," namely—
  - Wills' Creek, which *rises* in Somerset County, at the East base of the Alleghany Mountain; *traverses* the South-east corner of Somerset, North-west corner of Bedford, and the narrow part of Maryland; *passes* no important town; and *empties* into the Potomac at Cumberland.
  - Town Cr., which *rises* on the East slope of Tussey Mountain, in the South part of Bedford County; and *empties* into the Potomac below Old Town.
  - Sideling-hill Cr., which *rises* in the valley West of Townhill, in the South-east corner of Bedford; and *empties* into the Potomac above the mouth of the Cacapon River.
  - Licking Cr., which *rises* in Fulton County, East of McConnellstown Cove; and *empties* into the Potomac several miles East of Hancock.
  - Conecocheague Cr., which *rises* in Franklin County in Anderson's Valley —East Branch rises in the North-west corner of Adams' county; and *empties* into the Potomac at Williamsburg.

  All these streams traverse the narrow part of Maryland, after flowing out of Pennsylvania.

THE ALLEGHANY

THE ALLEGHANY

- *Rises* near the centre of Potter County, at an elevation of about 1700 feet above the sea.
- It *traverses* the west part of Potter, N.E. corner of McKean, then enters New York, and returns into Pennsylvania in the N.E. corner of Warren County, which it traverses diagonally, and passes through Venango, Clarion, and Armstrong, and between Butler and Alleghany, where, at Pittsburg, it drops its name and takes that of the Ohio, passing between Butler and the rest of Alleghany County, and then across Beaver County, to become the dividing limit between the States of Ohio and Virginia.
- It *receives*
  - from the *right*,
    - the Conewango Creek,
      - which *rises* in Cattaraugus County, New York;
      - *traverses* Cattaraugus County, New York, and the North part of Warren County, Pennsylvania;
      - *empties* at Warren into the Alleghany.
    - the French Creek,
      - which *rises* in Chatauque County, New York, not far from Chatauque Lake;
      - *traverses* the S.W. corner of Chatauque County, New York, and Erie, Crawford, and part of Venango counties, Pennsylvania;
      - *passes* at or near the *town* of Meadville;
      - and *empties* into the Alleghany at Franklin.
    - the Beaver River,
      - which *rises* under the name of Chenango, the main Pennsylvanian stem, in the N.W. corner of Crawford County, West of Conneautville;
      - *traverses* West sides of Crawford, Mercer, Lawrence, and Northern half of Beaver counties;
      - *passes* at or near the *towns* of Lawrence, Newcastle, Sharon, and Greenville;
      - It *receives*
        - from the *right*—the Mahoning River, which *rises* in the Lake Water-shed in Ohio, *traverses* Summit, Portage, Warren, and Mahoning counties of that State, and *empties* into the Beaver or Chenango in Lawrence County, below Newcastle;
        - from the *left*—Neshannock Creek, which *traverses* Mercer County, and *empties* into it below Newcastle and Slippery-rock Creek, which traverses Butler, a part of Lawrence, and empties into the Beaver near the North line of Beaver County;
      - and *empties* into the Alleghany at Beaver.
  - from the *left*,
    - the Tionesta Creek,
      - which *rises* in Warren County;
      - *traverses* the S.E. portion of Warren, and Eastern part of Venango Counties;
      - and *empties* into the Alleghany at Tionesta.
    - the Clarion River,
      - which *rises* in the South part of McKean County, at an elevation of nearly 2000 feet;
      - *traverses* Elk, S. edge of Forest, and middle of Clarion counties;
      - *passes* at or near the *towns* of Ridgeway and Clarion;
      - and *empties* into the Alleghany at Foxburg.
    - the Red-bank Creek,
      - which *rises* in the Western border of Clearfield County;
      - *traverses* centre of Jefferson and Northern border of Armstrong counties;
      - *passes* at or near the *town* of Brookville;
      - and *empties* into the Alleghany near Vanburen.
    - the Mahoning Creek,
      - which *rises* in the Western border of Clearfield County;
      - *traverses* Southern side of Jefferson, and Northern side of Armstrong counties;
      - *passes* at or near the *towns* of Punxatawney and Nicholsburgh;
      - and *empties* into the Alleghany some miles above Kittanning.
    - the Crooked Creek,
      - which *rises* in the interior of Indiana County;
      - *traverses* West part of Indiana, and Eastern half of Armstrong;
      - and *empties* several miles below Kittanning.
    - the Conemaugh, or Kiskiminetas River,
      - which *rises* in the Eastern border of Cambrian County, in the Alleghany Mountain;
      - *traverses* the breadth of Cambria County, and the whole Northern border of Westmoreland;
      - *passes* at or near the *towns* of Johnstown, Bolivar, Blairsville, Saltsburg, and Leechburg;
      - and *empties* into the Alleghany at Freeport.
    - the Monongahela River,
      - which *rises* in Virginia, in Lewis County;
      - *traverses* Lewis, Harrison, and Monongalia counties in Virginia, and divides Fayette and Westmoreland from Green and Washington, North of which it traverses Alleghany County to Pittsburg;
      - *passes* at or near the *towns* of Morgantown, Greensburg, Brownsville, Williamsport, Elizabethtown, and McKee's Port;
      - *receives* from the *right* the Cheat River, which *rises* in Virginia in the backbone of the Alleghany Mountain, and *empties* into it a short distance North of the Stateline, and the Youghiogheny, which *rises* in the Backbone Mountain, *traverses* Hampshire county, Virginia, northward, and Somerset, Fayette, and Alleghany counties, Pennsylvania, north-westward, *emptying* into it at McKee's Port;
      - and *empties* into the Alleghany at Pittsburg.
    - the Chartiers Creek,
      - which *rises* in the centre of Washington County;
      - *traverses* the Northern half of Washington, and Southern half of Alleghany Counties;
      - *passes* at or near the *town* of Washington;
      - and *empties* into the Alleghany three miles below Pittsburg.
- It *passes* by or near the *towns* of Coudersport, Olean, Warren, Franklin, Kittanning, Freeport, Pittsburg, and Beaver;
- It *empties*, or more properly, it changes its name at Pittsburg into the Ohio River, which empties into the Mississippi River at Cairo, the Southern point of the State of Illinois.

SCENERY ALONG THE PRINCIPAL RIVERS.

The Delaware River.—This noble river, the eastern boundary of Pennsylvania, throughout its entire breadth exhibits, along its immediate valley, a considerable variety of topographical feature and scenery. From its head-streams in New York, to where it emerges from the Pokono or Catskill Mountain, it flows in a tortuous course through a deep narrow trough in that elevated table-land. The mean level of the plateau remaining nearly constant, and the valley growing progressively deeper, the river-hills, which are all that the traveller at the river-side usually beholds, grow higher and steeper as he descends. Meandering much more than the valley containing it, the river sweeps sometimes close by the base of the bounding hills, the lower parts of which are, in many cases, faced by high naked cliffs, exposing the reddish brown shales and sandstones of the district, in beautiful contrast with the mixed green hues of the foliage. The perspective of jutting and retreating hills, clothed for the most part with a combination of coniferous and deciduous forest to their summits, and washed at their base by long bending reaches of the broad river, are very attractive, notwithstanding a prevailing sameness in general feature. After leaving the plateau in Pike and Wayne counties, the river emerges into a broad open valley, wholly different in aspect and structure from that which it has left. The waters which carved a way for it seem to have been impelled in their momentum southward, with great energy, against the strong stony barrier of the Kittatinny or Shawangunk Mountain, and to have scooped their deepest trench near the base of that high ridge. The river, therefore, turns abruptly at Carpenter's Point, from a S.E. to a S.W. course, and follows the foot of the mountain, sometimes hugging its base, sometimes sweeping a moderate distance from it into the plain, until it finds a passage through it by the great breach called the Delaware Water-gap. The scenery along this stretch of the river is eminently beautiful. Low within the valley, the river is bordered by fertile cultivated flats, variously carved in one or more terraces ; and behind these, particularly on the N.W., rise numerous rolling hills, some under the plough, some covered with timber, all deeply cut by ravines, in the steeper of which are many beautiful waterfalls, while still beyond the hills we see ascending the long slopes or bold escarpments of the plateau of the Upper Delaware. All the way along on our left the view is bounded by the forest-covered flank and straight crest of the Kittatinny Mountain.

Turning at the Water-gap, the Delaware, in issuing through the main ridge of the mountain, passes between steep, nearly perpendicular, mural cliffs of grey sandstone, rising on either side to its very crest. The sketch of this scene from the S. will give some notion of its character.

Leaving the Water-gap, the river descends gently southward, obliquely across the entire breadth of the Appalachian Plain or Valley, to where it enters the hills called "The South Mountains," below Easton. This portion of its course is marked by no striking features, the surface of the country being elevated only 100 or 200 feet above it, and being, from the softness of the slates and limestones, smoothed down into rather inexpressive lines.

Below the mouth of the Lehigh, the Delaware is bordered by an alternation of hills and narrow intervening valleys, the river-hills being but the ends of the intersected ridges of the low chain of the Highlands of New Jersey ; but from the southern edge of these hills, at Durham, the scenery for many miles southward wears a wholly different character. It is that of a table-land, elevated 300 or 400 feet above the level of the river, cut on one or both sides of the valley into long ranges of perpendicular precipices, or extremely steep slopes. One stretch of precipice on the Pennsylvania side, known by the name of the Nockamixon Rocks, is an exceedingly striking and picturesque range of beetling cliffs, rising sheer for 200 or 300 feet from the brink of the river, with only a narrow roadway between them, through a length of nearly 3 miles. Some of the views from the base of these crags are almost grand ; and the pictures they make with the river below are beautiful. Tufts of bushes and trees, and climbing vines, heighten by their green hues the rich brown tints of the rocks, to the bold faces and narrow ledges of which they lend a grace which no cliffs without vegetation ever possess. There are few more attractive drives or walks by the river borders of Pennsylvania than this one at the foot of the Nockamixon Rocks.

Further down its valley the Delaware passes, in the vicinity of New Hope, some bold ridges of trap-rock, which impart a pleasing variety to banks, elsewhere, in this part of its course, comparatively tame. Passing Trenton, its borders presently put on a totally changed aspect. Ceasing to be a gay running stream, full of bushy islands, and rocky reefs, and rapids, it becomes a wide tidal river, rising and ebbing between shores which are in many places only low banks of sand and gravel, and in others, broad slimy marshes, covered with reeds and grass. Turning at Bordentown south-westward, the river maintains these features all the way to its wide estuary, the Delaware Bay.

The Susquehanna River—North Branch.—That portion of the Susquehanna River which flows near the northern boundary of the State, passes from its sharp elbow, called "The Great Bend," to the mouth of its affluent, the Chemung River, through a charming broad valley, bounded by soft slopes, terminating in wide table-shaped hills. It is a fertile and very beautiful district : and with its westward extension, the plain of the Chemung River is rapidly becoming one of the most attractive agricultural districts of New York. From the mouth of the Chemung River to Pittston, where the river suddenly turns at a right angle on entering the Wyoming Coal-field, it flows, with many bendings, along a deep and picturesque valley, almost identical in its features with that of the corresponding sketch of the Delaware, the main difference being, that the bed of the valley is wider, and the hill-sides confining it less mountainous. From the mouth of the Lackawanna at Pittston, where it enters, to Nanticoke, where it leaves the beautiful Wyoming Valley, the scenery along the river is wholly different. It flows through a broad and almost perfectly level smooth plain—the Wyoming and Kingston Flats—composed of a deep bed of diluvium or drift. On either side of this plain rise the rolling hills of the coal-basin, and behind these the long gentle slopes of the high mountain-barriers which frame in the whole scene. At Nanticoke the river turns abruptly northward out of the coal-basin, through its steep barrier, by a highly picturesque pass, and then sweeps again as suddenly westward, to run for several miles in a closely-confined trench, between the outer and the inner ridges of the basin. It does not, however, run round the western end of this, but at the ravine of the Shickshinny turns suddenly southward, and cuts across its point, leaving a high insulated hill of the coal strata on its western or right-hand side. Disengaging itself by a fine pass from the southern barrier of the coal-basin, it passes out into an open valley, and makes another rectangular bend, to run once more towards the W., parallel with the Nescopeck Mountain, which it follows to the neighbourhood of Catawissa. Beyond this point it maintains its general course westward, somewhat S., parallel with the southern base of Montour's Ridge, all the way to Northumberland, where it is joined by its great tributary, the West Branch. In some portions of this long reach of the river, the scenery adjoining it is uncommonly rich and pleasing. A remarkably fine view up the river is presented from the hills on its west bank, a little below the mouth, of Fishing Creek.

Between Northumberland and the Kittatinny Valley the river leads us through many striking scenes. It is studded with many little islands, most of which are covered with trees or bushes to the water's edge ; and it is here a wide and majestic river, flowing alternately for long reaches, across highly cultivated belts of country, and past the ends of steep and rugged mountains. (The View of the river at the gap of the second mountain will convey some notion of the appearance of its banks.) (The Scene, embracing the Blue Hill at Northumberland shows the junction of the North and West Branches, and gives a just conception of the style of the hills bounding its immediate valley.) Passing out from the mountains, it traverses a beautiful country in the Kittatinny Valley, dividing Dauphin from Cumberland County. There are superb views of this reach of the river from Harrisburg, from the dome of the Capitol, and also from the southern slope or summit of the Blue or Kittatinny Mountain ; and again from the high hills on the edge of York County. Quitting the Limestone Valley, the river next traverses the Red-shale Belt, between the villages of Highspire and Bainbridge, crossing a rather monotonous country, except at the Conewango Falls, or Rapids, where numerous hard trap-dykes impede its course, and cause it to rush in wild tumult, by deep and dangerous sluices, for a long distance between black and jutting reefs. At Chiques Ridge, one mile above Columbia, the river leaves the smoother country, and passes between a range of high and picturesque crags. With two or three intermissions, caused by the softer limestone valleys which it next crosses, it runs the whole way thence to the vicinity of Port Deposit, or nearly to the head of the Chesapeake Bay, between steep, naked, and half-naked hill-sides, rising from 200 to 400 feet above its channel. In some parts of this long reach, as at the mouth of the Conestoga, the river is greatly dilated, and is filled with rocky islands and projecting reefs. In other localities its rugged banks approach, and the river rushes with tremendous force, especially during freshets, through these deeper gorges. The traveller, who finds only a rough and very toilsome path along its eastern shore, from Turkey Hill to Port Deposit, a distance of more than thirty miles, will choose to descend it by its right bank along the tow-path of the Canal. He will pass an almost unbroken succession of interesting rocky scenes, affording much geological instruction ; and he will witness many beautiful bits of river perspective, but he will find himself pent in all the way between the bold river-hills.

West Branch of Susquehanna.—The upper part of the West Branch of the Susquehanna, and also its tributaries, the Sinnemahoning, Kettle Creek, Pine Creek, &c., draining the high plateau N.W. of the Alleghany Mountain, flow through deep trenches in the horizontal strata, very analogous in their features to those which give passage to the Delaware, and the Main, or North Susquehanna, in the north-eastern part of the State. From the mouth of the Sinnemahoning, out into the Bald Eagle Valley, the river-hills are very high and steep, and admit extremely narrow strips of level ground between their feet and the river, except near the openings of the lateral streams. The trough through which the lower half of Pine Creek flows is equally profound. A notion of the appearance of this high table-land, where the larger streams intersect it to its base, may be gleaned from the little outline Sketch, showing the hills near Young Woman's Creek.

Entering the valley between the Alleghany Mountain and the Bald Eagle Ridge, the river pursues a beautiful winding-course the whole way from Lock Haven to the neighbourhood of Muncy, alternately sweeping towards the middle of the cultivated valley and back again, close into the base of the steep and wood-covered ridge. Near Muncy it turns with a broad majestic curve round the end of the Bald Eagle Mountain, and in a few miles deflects from a S.W. to a S. course, through a highly fertile, richly cultivated, open country, till it strikes the base of the Blue Hill, or range of Red Sandstone Cliffs above Northumberland. S.W. of Muncy the river crosses a singular belt of deeply-eroded country, full of conical hills. Our Picture (see Plate) represents these Muncy Hills, the river, and the point of the Whitedeer Mountain. All this lower reach of the West Branch abounds in charming scenery, if the observer is at the pains to ascend one of the mountain-spurs or hills, high enough to open sufficiently expansive views.

The Juniata River.—This second great tributary of the Susquehanna has two chief upper divisions, the Frankstown and the Raystown Branches, both of which, like the main stream below their junction, traverse much beautiful scenery. We will trace the Frankstown Branch as that which is most accessible. After gathering its head-waters from the eastern slope, and the foot-hills of the Alleghany Mountain, it begins to assume the volume of a small river near Frankstown. Below this point it first passes the Cove of the Lock Mountain, a curious district of conical hills, in structure very like the Muncy Hills of the West Branch. Its course is now by a wild and rocky gorge through the Lock or Canoe Mountain, into Canoe Valley. Winding north-eastward through this valley, it next goes through Tussey Mountain into Hartslog Valley by an interesting curving pass of the form of the letter S. The mountain, which consists of two ridges, is trenched along its centre for the passage of the river, and the western ridge is moreover breached at Water Street by a lateral notch, which gives passage to a small tributary stream, and heightens much the picturesqueness of the place, which is further enhanced by a great stone-slide covering the ends of the mountain. Crossing Hartslog Valley, it next traverses Warrior Ridge, passing by the Pulpit Rocks, one view of which is exhibited in the frontispiece to this volume. Emerging from the Warrior Ridge, and deflecting more towards the east, it crosses the Huntingdon Valley and passes by the northern end or knob of Terrace Mountain and Sideling Hill, receiving first the Raystown Branch, which nearly doubles the volume of its waters. Here bending southward, it follows a picturesque gap through Stone Ridge—a sketch of which, at the Canal, is given in this work—and turning more eastward, it presently enters the deep cleft in Jack's Mountain, called "Jack's Narrows," upon the western side of which the mountain is covered with a great stone-slide, or field of naked angular blocks of sandstone, which imparts a most desolate aspect to the pass, especially when the forest is not in leaf. On emerging from Jack's Narrows, the river crosses a succession of open valleys divided by narrow ridges, until it meets the base of Blue Ridge in Sugar Valley. There it makes a great loop, turning in an ox-bow backward, till it reaches Newton Hamilton, whence it flows with many large sinuosities, longitudinally, through the Juniata or Lewistown Valley, to the deep synclinal ravine called the "Long Narrows," formed by the near approach of the Blue and Shade Mountains.

The Picture of the Lewistown Valley, as it appears from the ridge west of Lewistown, which is given in this work, will sufficiently exhibit the character of its scenery.

Lehman

WEST BR. OF THE SUSQUEHANNA, FROM THE MUNCY HILLS.

The Long Narrows of the Juniata is a narrow trough between mountain-ridges, deeply trenched on their flanks, and thickly clothed with timber on their lower slopes and at their base, and overspread nearer their summits with extensive sloping sheets of dark-grey angular blocks. The pass is seven miles long, and is one of the wildest and most impressive within the mountains. At the eastern end of the Long Narrows, the river turns south-eastward, and winds between hills and valleys across the country, to the base of the Tuscarora Mountain, passing Mifflintown, Mexico, and other villages. This is one of its most beautiful districts ; but the finest views are not immediately upon the river, but from the higher hills which overlook it at a moderate distance. Below New Mexico it sweeps the base of the Tuscarora Mountain for several miles, until it turns abruptly across its eastern end, a mile N.W. of Millerstown. The pass by which it traverses the end of the mountain is a simple notch, much less grand than some of the other water-gaps; but the long straight reach of the river, before it enters the notch, furnishes a fine view of the beautifully symmetrical form of the Tuscarora Mountain stretching for a great distance. Below Millerstown the river crosses the Wildcat and Buffalo Valleys, washing the end of the Buffalo Mountain. We get superb views of the terminal knob of this ridge, which in shape is like the curving hump and neck of the Bison that once frequented the region, with the river and its tree-covered banks in the foreground. Pursuing its course, the Juniata, after making two or three bends, goes through a belt of hills called the " Half-fall Mountain," where, as at nearly all its passes through the larger sandstone ridges, it is impeded by ledges of hard strata, and thrown into ripples or rapids. From the Half-fall Rapids it flows between steep but low cliffs and hills, for about four miles further, to its entrance into the main Juniata, at Duncan's Island, having followed a winding course entirely across the central zone of the Appalachian Chain, through a distance of nearly 200 miles.

THE ALLEGHANY RIVER.

I shall complete this sketch of the chief rivers of Pennsylvania with a concise description of the Alleghany, but shall omit any specific account of its local scenery, as the topographical and pictorial features of the wide region watered by it, and by its tributaries, have been already sufficiently delineated.

The Alleghany, from its sources to where it becomes the Ohio River, flows through a deep and comparatively narrow trench, excavated in the north-western plateau, and western coal-basin of the State. From the centre of Potter County, where it takes its rise, it runs with a somewhat swift descent westward, and then northward in a curving course, till it enters New York. There it takes a wide sweep north-westward into Cattaraugus County, passing Olean, to pursue from near Valley Creek a long sinuous south-westward course, to its great bend at Franklin. Edging its way gradually into the coal-basin, the north-western margin of which it enters near Warren, it takes an abrupt turn at the mouth of French Creek, and runs across the coal-field south-eastward to the mouth of the Mahoning, traversing entirely the sixth or last sub-basin, and entering the fifth or that of Brookville and Kittanning. Near the mouth of the Mahoning, the River Valley suddenly departs from its previous south-eastward trend, to resume its normal S.W. direction, or to follow the length of the coal-basin. This it does by a succession of convex and concave sweeps to Pittsburg, where, upon receiving its noble tributary, the Monongahela River, it deflects north-westward at right angles, and stretches to the mouth of the Beaver River, where it makes another rectangular elbow, flexing to the S.W. to leave Pennsylvania, and pass into the State of Ohio.

A little attention to the relations of the present drainage of the country, to the general scooping of the surface by the primeval waters which shaped it, will show us why the Alleghany River assumes the remarkable rectangular changes of direction which we have above noted; first flowing S.W.; thence from French Creek to Mahoning south-eastward; thence to Pittsburg south-westward again; thence to Beaver north-westward; and once more from Beaver south-westward into Ohio. It is evident that, while the main discharge of the denuding wave was south-westward, or down the broad trough of the bituminous coal-field, one large influx of eroding waters swept the basin north-westward from the Appalachian Mountains, and another south-eastward from the region of the lakes. Thus it has arisen that all this western district of Pennsylvania is trenched by three main systems of valleys, as respects their directions; chief valleys stretching south-westward, other valleys opening into these at right-angles, or north-westward and northward, and a third set also opening at right-angles into the same first system south-eastward and southward.

The streams of the north-western slope, or those draining into Lake Erie, are relatively too insignificant to merit here the kind of description called for by the Delaware, Susquehanna, Juniata, and Alleghany Rivers. We pass, therefore, now to a brief sketch of the Climatology of the State.

CLIMATOLOGY OF PENNSYLVANIA.

As respects its climate, Pennsylvania is very fortunately related to the rest of the United States. Owing to its midway station in the Appalachian Chain, between the cold region of the Gulf of St Lawrence and the tropical heats of the Gulf of Mexico, it enjoys, in point of temperature, a climate nearer to the medium of that of the whole country than any other district on the Atlantic side. This temperate condition is also partly due to the softening influence of proximity to the Atlantic Ocean on one side, and Lake Erie on the other, for—unlike any other State except New York—its one slope rests upon the tide, and its other upon the Lawrentian Lakes. Like all the wide belt of country S.W. of New England, which is centrally traversed by the Appalachian Chain, and has the Atlantic Slope on the one border and the slope into the Ohio Basin on the other, Pennsylvania possesses three climates; but from the cause already assigned—the proximity of the Ocean and the Lakes—these climates are tempered from the more extreme types they exhibit in the other parts of this zone. The Atlantic Slope, including the tide-water plain at its base, is much wider throughout the Southern States, and both it and the mountain-chain behind it are therefore further removed from the influence of the ocean; and, again, the Western Slope of the State, by its inland position, is so far withdrawn from the hot plain encircling the Gulf of Mexico, that the S.W. wind of the continent, a most important element in our climates, is materially tempered in both its heat and humidity. To these sources of a comparatively equable climate, should be added the relatively lower elevation in Pennsylvania of the mountain-chain, the mean height of which increases towards both the N.E. and the S.W.

My object here is to present merely a general outline of the climatal features of the State, there being no room in this work for local details on this subject. I shall therefore best succeed by presenting the chief climatal elements of temperature and moisture, in their average and extreme amounts.

Temperature,—Average of the Year.—The mean or average temperature of the entire State is very nearly 47°, or about that of the Island of Great Britain. When we contrast the latitudes of the two countries, the mean of the one being scarcely as high as lat. 41°, that of the other being lat. 54° 20′, this coincidence of mean temperatures is not a little remarkable. It is interesting as indicating why this portion of the United States seems more congenial than any other to the British, German, and other populations emigrating to America from the north temperate climates of Europe.

The Northern Border of the State has a mean temperature, with a certain fluctuation due to height, of about 45°, but the north-western corner or western part of this northern belt possesses a mean annual heat of about 47°, the difference being evidently due to the ameliorating action of the broad surface of Lake Erie.

The Southern Border, or rather the belt S. of a line stretching from Easton to Pittsburg, has a mean temperature of about 50°. So marked a difference in the temperatures of the northern and southern sides of the State, equivalent to a change of 1° of Fahrenheit for every 25 or 30 miles difference of latitude, contrasts strikingly with the more gentle gradations of climate in Western Europe and on the Pacific side of North America, where the average rate of variation is at the least 60 miles, or 1° of latitude to 1° of temperature. It is plain, therefore, that Pennslyvania, in common with all the country north of it as far as Hudson Bay, contains, for its breadth in a N. and S. direction, a remarkably wide range of climates. In other words, it has its different climatal zones very closely compressed.

A given mean annual temperature will not be found to range due E. and W. across the State; but the *Isothermal Lines*, or those marking identical average heat, are deflected southward where they cross the mountains. This arises from the circumstance that elevation above the sea, especially where the mountains are near it, is a main cause of coolness. So that we must go S. along the mountains a certain distance to find the same temperature which we have been tracing towards them over the plains. In crossing the Appalachians of Pennsylvania, the mean annual heat, under the same latitude, appears to decline about 3°, and therefore the *Isothermal Lines* must swerve to the southward in the highest portions of the chain about 75 or 100 miles, resuming their latitude when they descend into the plain of the Alleghany and Ohio River. These are the conditions of the average heat of the whole year; let us look next at the relations of temperature for each of the four seasons.

Mean Temperature of the Spring Months.—According to the temperature charts and tables, published recently by Mr Lorin Blodget, our best authority on the climates of the United States, the average temperature for the three spring months of the southern edge of the State is about 50°, while that of its northern border, excepting the Lake Slope, where it is 45°, is very nearly 44°. Thus the spring mean temperature of the entire State is about 47°, or the same as that of the whole year. The Mountain Zone is cooler by 2° or 3° than the South-eastern and North-western Slopes. But elevation appears to exert a less sensible influence in reducing the temperature in the spring than during either of the three other quarters of the year.

Summer Mean Temperature.—The mean temperature of summer of the southern half of the State is about 70°, and that of the northern half about 67°; but at this season the Mountain-zone is so much cooler than the Atlantic and Western Slopes, that to get a clear notion of the summer climates we must divide the State, for this period at least, into its three Belts,—a south-eastern, a middle, and a western. Thus the mean summer temperature of the district between the tide-water and the first range of mountains is about $72\frac{1}{2}°$; that of the Mountain Belt is about 67°; and that of the western side of the State, very nearly 69°; in other words, the cooling influence of the mountains, contrasted with the Atlantic Slope, is equivalent to a mean difference of $5\frac{1}{2}°$, or more than twice their effect in the spring season. The difference of $3\frac{1}{2}°$ between the eastern and the western slope or plain, is evidently somewhat more than is due simply to a difference of elevation, and must be ascribed in part to the proximity of the Atlantic Slope to the low, warm plain of the tidal sea-board of the Southern States. The mountain climate of the State, as might be inferred from its average summer temperature of 67°, is eminently tonic and salubrious to constitutions debilitated by the greater and more protracted heat of the lower country.

Autumn Mean Temperature.—The average temperature of the whole State in the autumn seems to be about 50°, that of the Atlantic Slope approximately 54°, and that of the Ohio Slope about 52°. At this season the cooling influence of height is very sensibly felt in the mountains; it is indicated in the much earlier arrival there of frost and snow than in the south-eastern and western plains.

The Winter Mean Temperature.—Elevation exerts at this season of the year so marked an influence in the distribution of temperature, that it is expedient again to consider the climatal zones as coinciding nearly with the three great Orographic divisions of the surface—the two slopes and the intervening mountain-chain. So viewed, the Atlantic Slope has, for this season, a mean temperature of about 30°, the Mountain Belt approximately 24°, and the Western Slope nearly 28°. It is an important feature in the climate of the southern border of the State that the mean winter temperature of 32°, or the point of freezing and melting, lies along a line just coincident with the edge of tide-water, touching Trenton, Philadelphia, and the Susquehanna, near Port Deposit.

Summary.—From the above data, it would appear that the Atlantic slope exhibits a range from mean winter to mean summer temperatures of $42\frac{1}{2}°$, namely, from 30° to 72°.5; the Mountain Chain a like range of 43°, namely, from 24° to 67°; and the Western Slope a similar one of 41°, namely, from 28° to 69°.

The corresponding mean annual range for the climate of Great Britain is *about* 20°.

Extremes of Temperature.—The climate of Pennsylvania exhibits, like every portion of the United States east of the Rocky Mountains, very wide extremes of temperature, both periodic, or annual and diurnal, and non-periodic, or casual, namely, sudden rises and falls of heat connected with the shiftings of the weather. These oscillations are, however, less extreme in the Middle States than in perhaps any other district of the eastern half of the continent, certainly less extreme than in New England and the States west of the Mountains.

The Mean Maximum Temperature for the summer season, averaging the whole of Pennsylvania, is about 74°, and the *Mean Minimum Temperature* for the same is about 65°. These are important data for indicating the adaptation of the climate for certain crops, for it is the summer of the year, more than any other portion of it, which has a critical relationship to agriculture. The summer temperatures and the summer moisture control all vegetable life, and even animal life, to a large extent; and upon them depend many of man's most important interests. The extremes of summer and winter temperatures are the most important of the limiting conditions of life, determining what plants and animals can, and what cannot, flourish naturally or through artificial culture, and a correct statement of them is fully as essential to the thorough definition of any climate as the mention of its annual, seasonal, and monthly mean temperatures. It is to be regretted that the casual or non-periodic oscillations of weather have hitherto received from meteorologists, in their descriptions of climate, so little attention. Up to the present time there is almost no temperature-chart before the public which indicates, in addition to mean isothermal temperatures, the known or possible extremes of heat and cold for each district or zone of country. In the present incompleteness of the published records of temperature, I find it difficult to procure a statement of the extremes of heat and cold to which the interior localities of Pennsylvania are liable. Mr Blodget's excellent treatise on the Climatology of the United States furnishes ample data concerning the thermal fluctuations at Philadelphia, and I must content myself with presenting, in the most condensed shape, a simple statement of these. In place of exhibiting the vicissitudes of temperature for every month of the year, I prefer, for the sake of brevity, to introduce only those of the five warmest months and the three coldest, since these contain nearly all the elements which are useful for the comparison of the extremes of one climate with those of another, and all the conditions influential to agriculture, horticulture, and the other arts especially affected by climate.

The following Table exhibits not only the greatest degrees of heat and cold felt in each of the eight months referred to, over a term of nearly sixty years ending with 1856, but it also states the lowest or coolest maximum temperature experienced, and the highest or warmest minimum in each month :—

MAY,	Highest maximum, or greatest heat known,	94°	Lowest maximum, or least heat known,	71°
	Lowest minimum, or greatest cold known,	32°	Highest minimum, or least cold known,	55°
JUNE,	Highest maximum,	98°	Lowest maximum,	81°
	Lowest minimum,	42°	Highest minimum,	62°
JULY,	Highest maximum,	98°	Lowest maximum,	86°
	Lowest minimum,	55°	Highest minimum,	65°
AUGUST,	Highest maximum,	96°	Lowest maximum,	85°
	Lowest minimum,	50°	Highest minimum,	69°
SEPTEMBER,	Highest maximum,	93°	Lowest maximum,	78°
	Lowest minimum,	35°	Highest minimum,	55°
DECEMBER,	Highest maximum,	72°	Lowest maximum,	44°
	Lowest minimum,	2°	Highest minimum,	25°
JANUARY,	Highest maximum,	66°	Lowest maximum,	40°
	Lowest minimum,	−10°	Highest minimum,	24°
FEBRUARY,	Highest maximum,	70°	Lowest maximum,	44°
	Lowest minimum,	7°	Highest minimum,	17°

The above record of temperatures, remarkable as it is, fails to show the extreme degrees of heat and cold, especially the latter, which belong occasionally to the climate of Philadelphia. It is stated by Blodget, on the authority of Pierce, that in 1780, which was the coldest winter known until the two last, 1856 and 1857, "the Delaware River was closed from the 1st December to the 14th March, and that during the month of January the mercury was several times between 10° and 15° below zero, and only once during the month as high as 32°." The winter of 1783-1784 seems to have been almost as intensely cold.

Philadelphia, seated on the tide-water, does not offer, however, a fair specimen of the climate, or rather climates, of Pennsylvania. Its winter extremes of cold are less by many degrees than those experienced in higher and more interior localities; while its extremes of heat are only a little if at all greater. Thus at Lambertsville, on the Delaware, a station which represents very fairly the climate of the Atlantic Slope of New Jersey and Pennsylvania, the highest maximum temperature during nineteen years, ending with 1855, is recorded at 100°; while the lowest minimum is given at $-16°.5$. This exhibits a range of $116°.5$; or 5° or 6° greater than the range at Philadelphia. The ordinary or *mean* annual range for this city is 85°. This is the difference between the average of the extreme coldest temperatures of all the winters for sixty years, and the average of the extreme warmest for the same term. As an illustration of the difference between Philadelphia and the interior in their degrees of extreme winter cold, the winter of 1835, an uncommonly severe one, showed a cold of $-22°$ at Lancaster, and of $-24°$ at Pottsville; while at Philadelphia it was only $-6°$. Again, in 1856, while the lowest temperature at Philadelphia was $-7°$, that at Pittsburg was $-18°$.

Rain Averages for the Year.—Few districts of the United States, or indeed of the world at large, are more fortunately circumstanced as to rain than Pennsylvania. Lying within the belt of the non-periodic rains, it is blessed with a singularly equable distribution of moisture throughout the year. The State is seldom visited by a drought of more than six weeks' duration, generally occurring, when it does take place, in the latter half of the summer. These dry periods, hardly more frequent than once in four or five years, are rarely so severe as those which visit the west and some other parts of the country. It is, in like manner, comparatively exempt from protracted and flooding rains. The rains of Pennsylvania, New Jersey, and Eastern New York take the form of brief, light, rain-storms of one, two, or at most three days' duration, and of intermitting showers; and these, excepting during the occasional summer and autumn droughts, are spread with remarkable impartiality over the several seasons, and even over all the several months of the year.

At Philadelphia and along the Atlantic Slope of the State, the average annual rain-fall amounts to 42 or 43 inches. In the Appalachian Chain and on the Ohio Slope, it is materially less. Thus, at Carlisle, the average for six years has proved to be only 34 inches; and at Pittsburg, the average for eighteen years is a little short of 35 inches. This difference in the atmospheric precipitation on the Atlantic Slope and in the mountains, is a curious exception to the general law of rain in many countries, where the mountains receive much more than the plains, even though the plains lie close to the sea. It would seem to imply, that the mountain rains of Pennsylvania are derived in considerable amount from the far-removed Gulf of Mexico, the S.W. wind from which has parted with a large share of its moisture on its journey, while the Atlantic Slope, or sea-board, receives an additional supply from the more local winds of the ocean.

At Philadelphia, the fall of rain for each of the four seasons averaged, during nineteen years ending with 1856,—for spring, 10.97 inches; summer, 12.45; autumn, 10.07; winter, 10.06.

At Pittsburg the respective amounts, during eighteen years ending with 1854, were,—spring, 9.38 inches; summer, 9.87; autumn, 8.23; winter, 7.48.

Extreme Quantities of Rain.—The total annual supply of rain fluctuates considerably in all parts of Pennsylvania, in accordance with the general non-periodic character of all the elements of its climate. Thus at Philadelphia, during twelve years, the fall in shape of rain and snow was one year only 35 inches, while another it was nearly 55 inches. At Pittsburg, during eighteen years, one year had 25.6 inches, while another year had 47.8 inches ; and Gettysburg, near the mountains, had, in different years, 30.2 inches, and 52.2, in a term of seventeen years. Still more remarkable are the yearly variations in the rain-fall at New York. In a term of nineteen years, ending in 1854, one year (1837) produced 65.5 inches, while 1840 gave rather less than 30 inches. It is stated by Mr Blodget, that in the Central States of the Union, about two and a half times the least observed quantity of water falls during certain years,—that in some years less than half the average descends, and in others nearly double the average quantity.

At Lambertsville, the greatest number of rainy days for eighteen years has been 118 ; the least number 85.

At Fort Mifflin, on the Delaware, below Philadelphia, the greatest number of rainy days recorded is 110, and the least number 86 ; while the greatest number of snowy days is 17, and the least number 11.

At Carlisle, the highest number of rainy days recorded is 93, the lowest number 68 ; and the highest number of snowy days 26, the lowest number being 19.

At Pittsburg, the greatest number of rainy days for any one year has been 153, the least number 101 ; while the greatest number of snowy days has been 35, and the least number 13. The average number of the latter being 25.

Comparing the conditions of rain near the Tide-water with those at Pittsburg, we find that, while the former enjoys 7 inches, or 20 per cent more actual rain and snow than the latter, the relation is reversed as to the number of rainy and snowy days, the western locality exceeding the eastern in nearly as great a ratio.

Prevailing Winds.—The dominant winds in Pennsylvania, as in so many other parts of the United States, are the westerly ones ; but its several regions differ materially in the proportionate amount of the winds from the various quarters of the compass. Adhering to our division of the State into its South-eastern, Middle, and Western Climatal Zones, we have the elements for comparing the winds of each in the excellent summaries of observations on wind and weather, contained in the Meteorological Tables of the Medical Statistical Report on the Army of the United States, prepared under the direction of the Surgeon-General. Collecting the data there recorded for the localities of Alleghany Arsenal at Pittsburg, Carlisle Barracks at Carlisle, and Fort Mifflin on the Delaware, during the twelve years from 1843 to 1854 inclusive, I find that the winds were as follows ;—the circle of the horizon being divided into eight equal segments of 45° each, the number of days within the year on which the wind blew from each of these directions was—

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Fort Mifflin (average of only six years), . . .	24	50	25	30	32	75	51	65
Carlisle Barracks (average of seven years), . .	16	17	73	26	24	18	126	53
Alleghany Arsenal, Pittsburg (average of twelve years),	49	42	26.5	16	27	59	55.5	46

It will be seen from the Table, that on the sea-board the most frequent wind of all is the S.W. This is likewise somewhat the most abundant wind at Pittsburg, but at Carlisle Barracks the W. wind greatly predominates over all the others ; though a part of the 126 days recorded as west wind is evidently the S.W. current undergoing a local deflection from the dying away of the lofty chain of the Blue Ridge, near this place, and the sudden opening thereby of the low Atlantic Plain to this somewhat pent-up breeze. All the three divisions of the State display a marked superiority of the winds of the north-westerly over the south-easterly half of the compass-circle. At Fort Mifflin, the three westerly winds—namely, S.W., W., and N.W., blow 191 days; while all the other five blow for only 161 days. At Carlisle Barracks, the predominant winds are the W., N.W., and E., occupying together 252 days; but it is evident that this locality, the only one within the Mountain Chain whose winds have been reported on, is not happily situated for the purpose. Its N.E. winds amount to but 17 days, while its E. winds blow for 73 days. These latter are plainly, in part, the N.E. currents, deflected by the topography of the country. At Pittsburg, all the five winds, S.W., W., N.W., N., and N.E., are of nearly equal frequency, the S.W. and the W. somewhat preponderating. The three other winds, the E., S.E., and S., are comparatively infrequent, and in this feature the region resembles closely the tide-water front of the State.

Situated just far enough to the south to escape the severity of the cold and humid N.E. wind of the New England coast, and the savage energy of the intensely cold parching N.W. blasts of the northern interior of the continent, and just far enough N. to avoid the full heat and sultriness of the humid and relaxing S.W. and S.E. winds from the Gulf of Mexico and the warm Atlantic, this happily placed region is endowed with a climate possessing fewer of the noxious qualities of the general climate of the eastern half of the continent, than any other equal territory seated between the Atlantic and the Rocky Mountains.

GEOLOGY.

GENERAL INTRODUCTORY CHAPTER.

CLASSES OF ROCKS EMBRACED IN PENNSYLVANIA.

An inspection of any good geological map of the United States, and the British Provinces, will show that Pennsylvania embraces only the more ancient systems of strata of this portion of the continent. It includes no deposits of the *Tertiary* or *Kainozoic age;* none belonging to the *Cretaceous* or *Greensand,* nor any referable to the somewhat older *Oolitic period.*

Tertiary and cretaceous strata border the State upon the S.E., in New Jersey, but they do not cross the Delaware River into Pennsylvania.

The strata upon which the surface-wash and soils of Pennsylvania repose, belong to the three oldest classes of the sedimentary rocks—namely, to the Gneissic, the Palæozoic, and the earliest Mesozoic; each, but especially the Palæozoic, being developed upon a scale of great magnitude.

No large masses of igneous or volcanic rocks of any description appear within the borders of the State, the only intrusive materials being a few bold dykes of trap-rock, and innumerable lesser veins of the granitic rocks, all confined to the south-eastern district.

Of the three groups of strata above mentioned, the gneissic, or ancient metamorphic rocks, and the mesozoic red sandstone formation, occupy about an equal extent of territory, and are limited to the south-eastern counties. The palæozoic rocks cover about nine-tenths of the surface of the State; they possess an enormous aggregate thickness; divide themselves into many series, which again subdivide into numerous formations; they include a great profusion of organic remains, and exhibit in their undulations every diversity of structural feature to be met with in the Appalachian Chain, and they enclose an extraordinary amount and variety of the mineral deposits most useful to the wants and purposes of civilised man, particularly coal, and the chief ores of iron.

A large proportion, therefore, of this work will be devoted to a description of these Appalachian Palæozoic formations.

Resting upon these three great groups of solidified or rocky strata are sundry loose superficial deposits, some of which are invested with sufficient interest to demand a general description. These are chiefly certain *soils,* the ferruginous loams of the hematitic iron ores, and the northern Drift or Diluvium.

The *Gneissic* or Hypozoic rocks of the State include nearly all the more common varieties of felspathic, hornblendic, and micaceous gneiss and mica-slate. Closely associated with these, yet belonging to a wholly different system of strata, are extensive formations of talcose and micaceous slates, indurated clay-slates, chloritic and steatitic slates, referable in strictness to the palæozoic system, but so thoroughly metamorphosed through diffused igneous action, as not to be easily separated in detail from the true gneissic class. To this group of the crystalline stratified rocks have generally been referred the altered Primal slates, and Primal white sandstone, and also the crystalline limestone, or white and bluish marble of Montgomery, Chester, and Lancaster counties; but I shall show that these great strata do not truly date with the proper gneissic group, or so-called primary rocks, but are of palæozoic age, and identical, in fact, with the widely-spread primal and auroral rocks of the fossiliferous or secondary period.

The Palæozoic Rocks, the full classification and detailed description of which will be introduced in a subsequent chapter, constitute a vast succession of fossiliferous strata, commencing (in ascending order) with the lowest fossiliferous deposits resting on the gneissic class, and terminating with the last or highest of the coal strata. A comparison between their numerous organic remains and those of the palæozoic strata of Europe has satisfactorily shown that these rocks were deposited, with certain interruptions, during all the four earliest periods of the five great European divisions of palæozoic time, namely, the *Cambrian*, *Silurian*, *Devonian*, and *Carboniferous* ages. Neither in Pennsylvania, nor in any other quarter of North America yet explored, have rocks of the fifth or latest palæozoic period, called the *Permian*, been discovered.

The prolonged succession of sedimentary actions, producing these enormous strata of the Appalachian system, ceased with the close of the Carboniferous era, the whole formative process being terminated by the upheaval of the ocean, in whose broad bed and around whose margin the deposits had been collected. In the region of the palæozoic basin of Europe there was a similar upheaval at the end of the Coal period; but it was more partial, leaving a reduced but still wide area of waters for the reception of the next subsequent group, the Permian. Though the Appalachian palæozoic strata represent, therefore, a somewhat less extended scale of geological time than the European, they compensate for this deficiency in their extraordinary thickness, in the abundance and variety of their organic remains, and in the number of the separate, well-defined fossiliferous horizons, or independent *platforms of extinct life* which these display.

As developed in Pennsylvania, the aggregate thickness of these ancient deposits is not less, according to measurements carefully executed, than about 35,000 feet, and the scale upon which some of the constituent formations were produced was proportionately grand. Some of these formations, well defined by their organic remains and their lithological composition, measure individually between 3000 and 5000 feet. The strata of the Appalachian system of Pennsylvania (and the description applies equally to those of other regions) exhibit a remarkable variety of mineral character. They may, however, be all embraced under the three prevailing generic classes of the sedimentary rocks, namely, *Sandstones*, *Slates*, and *Limestones;* enclosing as subordinate layers, lesser deposits of *coal*, *chert*, and *iron ore*.

The coarser mechanically-produced strata consist in a large degree of silicious fragments, partly forming thick and massive Conglomerates of quartz pebbles, partly grey and whitish quartzose Sandstones. Other formations of great thickness, and wide, horizontal expansion, have an argillaceous composition, and are of the class called Argillaceous Sandstones and Sandy Shales.

Many of these solidified sandy clays are brown and reddish ; others, of less thickness, are grey, greenish, and even yellow. The more purely argillaceous rocks of the system are certain enormous formations of clay-slates and shales, of very various aspects and textures. Some of these are grey and bluish ; others are red ; while certain others, again, consist of clay and sand stained by the red oxide of iron. Besides these, there is another important class deficient in the silicious ingredient, and abounding in clay and the carbonate of lime, in those proportions which constitute *marls* or calcareous shales. These are frequently variegated, showing many tints in comparatively thin alternating strata.

Not the least interesting and important class of the Appalachian rocks are the true Limestones. They consist for the most part of an union of carbonate of lime and carbonate of magnesia, though some of them contain only a small amount of the latter ingredient ; others, again, include much argillaceous matter, and some are very sandy, and should be called Shaly and Silicious Limestones.

All of these deposits are more or less fossiliferous. Their distinctive peculiarities of composition, their characteristic organic remains, and their constituents generally, will be dwelt upon in the subsequent parts of this work.

PART I.

METAMORPHIC STRATA OF PENNSYLVANIA.

INTRODUCTORY CHAPTER.

CLASSIFICATION OF THE METAMORPHIC STRATA OF THE ATLANTIC SLOPE OF THE MIDDLE AND SOUTHERN STATES.

BEFORE entering upon a special description of the older rock-formations of Pennsylvania, with which our detailed account of its geology must commence, it will be expedient, for a clearer understanding of their relations to each other, to present a concise sketch of the geological composition of the Atlantic Slope of the Middle and Southern States, of which the Formations in Pennsylvania are a portion.

Discarding from our present survey the newer deposits of the region, or those long, narrow, superficial troughs of unconformably overlying red and grey shales and sandstones of Mesozoic or middle-secondary age, which partially cover the older or crystalline and semi-crystalline strata, and restricting our attention to these, we shall find that, when carefully studied, they rank themselves—so far as they admit of subdivision at all—into three natural physical groups. All the sedimentary mineral masses, without exception, are in a condition of more or less metamorphism or transformation from the earthy to the crystalline state by heat, and therefore, in using the term in a critical sense, all of them are metamorphic rocks. In the more current conventional application of this word, however, only some of them pertain to the usually recognised metamorphic or gneissic series; others belong unequivocally to the Palæozoic or ancient life-representing system; while others, again, constitute an extensive intermediate group, not typically gneissic or granitoid in their degree of crystalline structure or metamorphism on the one hand, nor yet fossiliferous on the other, so far as the closest scrutiny reveals. For a long while—indeed, from the commencement of geological research in this district of the Atlantic Slope until the geological surveys of Pennsylvania and Virginia had disclosed the composition and structure of the region—all of these ancient and more or less altered strata, between the summit of the Atlantic Slope in the Blue Ridge and South Mountain and its base at the margin of Tide-water, were regarded and designated alike as Primary Rocks, and were supposed to constitute but one group, the oldest known to geologists. Early, however, in the course of those surveys, it came to light that by far the larger portion of the rocky masses of at least the middle and north-western tracts, including much of the Blue Ridge and of the Green Mountains, were of a different type and age from the oldest metamorphic or true gneissic system. The evidence in support of this conclusion was, first, an obvious and very general difference in the composition of the two sets of strata; secondly, a marked difference in their conditions of metamorphism; and thirdly, and more especially, a striking contrast in the direction and manner of their uplift, the plications and undulations of the less metamorphic series dipping almost invariably south-eastward, while the gneiss in many localities has no symmetrical foldings, but only a broad outcrop dipping to a different quarter. These structural dissimilitudes imply essential differences in the direction and date of the crust-movements which lifted and transformed the respective groups, and they led the geologists of Pennsylvania and Virginia to a conviction that, over at least many tracts, there would yet be discovered a physical unconformity both in strike and dip. It was not, however, till a relatively late date in the prosecution of the geological survey of Pennsylvania, that the geologist of that State detected positive evidences of this physical break and of a lapse of time between the two groups of strata, and established, by ocular proof, the correctness of the previous induction. This unconformity, reflecting so much light on the whole geology of the Atlantic Slope, was first clearly discerned in tracing the common boundary of the two formations from the Schuylkill to the Brandywine and the Susquehanna, but it was quickly afterwards recognised on the borders of the gneissic district N. of the Chester County Limestone Valley, and again soon afterwards in the Lehigh Hills at their intersection by the Delaware River.

Prior to the suspension of the geological survey from 1843 to 1851, the true Palæozoic age of the non-fossiliferous crystalline marbles, and semi-crystalline talcoid slates, and vitreous sandstones of the Chester and Montgomery Valley, had been clearly demonstrated by the State geologist through a comparison of the strata with their corresponding formations in a less altered condition further north; but it was not until the resumption of field research, upon the revival of the survey in 1851, that any distinctive fossils were detected in these greatly changed rocks, which, even in their original state, seem to have been almost destitute of the usual organic remains.

Assembling all the evidence which we now possess, we have in the Atlantic Slope, by actual demonstration, but one physical break or horizon of unconformity throughout the whole immense succession of altered crystalline sedimentary strata, and within this region but one Palæontological horizon—that, namely, of the already discovered dawn of life among the American strata. This latter plane or limit, marking the transition from the non-fossiliferous or azoic deposits to those containing organic remains, lies within the middle of the primal series or group of the Pennsylvania survey, that is to say, in the primal white sandstone, which, even where very vitreous, and abounding in crystalline mineral segregations, contains its distinctive fossil, the *Scolithus linearis*. The Primal slates beneath the sandstone, and in intimate alternation with it, possess not a vestige of organic life, nor has any such been yet discovered anywhere within the limits of the Atlantic Slope, or on the northern or western borders of the Great Appalachian Basin of North America, either in this lower primal slate or in the other semi-metamorphic grits and schists physically conformable with it, and into which the true Palæozoic sequence of our formations physically extends downwards. We have thus, then, two main horizons subdividing the more or less metamorphic strata of the Atlantic Slope into three systems or groups: the one, a physical break or interruption in the original deposition of the masses ; the other, a life-limit or plane denoting the first advent, so far as yet discovered, of organic beings. As these two planes are not coincident, but include between them a thick group of sedimentary rocks, separated from the lower physically, from the upper ontologically, we are fully authorised, in the existing state of research, to employ a classification which recognises a threefold division of all these lower strata. To the most ancient or lowest group, it is proposed in this work to continue the name of Gneiss, preferring, however, to call this division generically the *Gneissic Series*, employing sometimes the technical synonyme Hypozoic, proposed by Professor John Phillips for the lowest of the metamorphic strata. To the great middle group, less crystalline than the gneissic, and yet destitute of fossils, the descriptive terms Semi-metamorphic or Azoic are applicable. And to the third uppermost system, or entire succession of the American Appalachian strata, from the Primal containing the earliest traces of life to the latest true Coal rocks or last deposits of the Appalachian Sea, it is here proposed to affix, as for many years past, the well-chosen title conferred on corresponding formations in Europe, of the Palæozoic, or ancient life-entombing system or series. Thus we have the *Hypozoic* rocks, or thôse *underneath* any life-bearing strata ; *Azoic*, or those destitute of any discovered relics of life ; and *Palæozoic*, or those entombing the remains of the earth's most ancient extinct forms of once living beings.

The Atlantic Slope of Pennsylvania includes all these three systems of strata, but our first concern is with the lowest, or most ancient, the Hypozoic or Gneissic Rocks. It will be seen further on in our description of these, and of the Azoic strata, where the latter display their maximum amount of crystalline structure or metamorphism, that the members of the two groups often simulate each other so closely, and are indeed so identical in mineral aspect and structure, as to baffle all attempts at distinguishing them lithologically ; nevertheless, it will clearly appear from the evidence embodied in the sections illustrating this country, that they are distinct systems occupying separate zones, susceptible of delineation on the geological map.

At the time of the first construction of the general Geological Map of the State, the true limits separating the Hypozoic or Gneissic from the Azoic or Semi-metamorphic rocks were but vaguely understood, and the State geologist did not venture to define them on the map, but shaded the one system into the other ; indicating, however, what he has since proved, that the true gneissic rocks, in their south-westward course, pass out of the State at its southern boundary, a short distance E. of the Susquehanna, while the Azoic or talco-micaceous group, as a genuine downward extension of the Primal palæozoic series, widens progressively, going westward, until, from a very narrow outcrop at the river Schuylkill, it occupies at the Susquehanna the whole broad zone S. of the limestone valleys of the Conestoga and Codorus streams in Lancaster and York counties. Since the revival of the field-work of the survey, the dividing limit of these two sets of metamorphic strata has been traced and mapped with precision. To the S.W. of the Susquehanna, it has never, it is believed, been pursued through Maryland and the other Southern States, though one may readily discern it in going northward or westward from Baltimore, or ascending the Atlantic Slope in Virginia. In Maryland, it crosses the Baltimore and Susquehanna railroad about 12 miles N. of Baltimore, and it is intersected by the Baltimore and Ohio railroad a little E. of Sykesville ; it crosses the Potomac about 40 miles above Georgetown and the James River in Virginia, 40 or 50 miles W. of Richmond. The line of boundary is, however, not a simple one, but is intricately looped, in consequence of numerous nearly parallel anticlinal foldings of the strata, sending promontories or fingers of the older rocks within the area of the newer or semi-metamorphic, to the W. of their average boundary, and causing, of course, corresponding troughs, or synclinal folds of the newer, to enter, eastward of the average boundary, the general area of the older. The Atlantic Slope has received hitherto so little exact geological study, that we are as yet without the data for determining, with any precision, either the succession of its much-broken and closely-plicated strata, or the geographical limits which separate even the larger sub-groups. It is sufficient, however, for our present purpose, to show the existence, and the approximate range, of two great metamorphic systems, separated by a physical break, and the conformable relations of the later, or upper of these, to well-known lower Palæozoic formations of the Appalachian Chain.

BOOK I.

GNEISSIC ROCKS OF PENNSYLVANIA.

GENERAL DISTRIBUTION OF THE GNEISSIC OR ANCIENT METAMORPHIC STRATA.

The three Gneissic Districts.—Within the limits of the State there are three distinct tracts, or zones, of the Older Crystalline Gneissic Strata.

The First of these, which I shall call the Southern District, ranges from the Delaware at Trenton to the Susquehanna, south of the State line, and lies wholly S. of the Limestone Valley of Montgomery and Chester counties, except near its eastern end, where a spur of the gneiss encompasses it on the N., and extends thence eastward to Trenton, along the margin of the Mesozoic Red Shale. This, the largest of the gneissic tracts, breaks off to the W. of the Brandywine, in a succession of narrow tongues. Near the State line of Delaware it sends forward, however, through the S.E. corner of Chester County and the State of Maryland, a continuous and widening belt to the Susquehanna. It is widest in the meridian of Chester and Ridley creeks, where it spreads from near old Chester to within a mile and a half of the Paoli.

The Second Zone lies N. of the North Valley Hill, extends lengthwise from near Valley Forge to the West Branch of Octorara Creek in Lancaster County, and expands northward from the foot of the North Valley Hill to the southern edge of the Red Sandstone district, or Valley of French Creek and south base of the Welsh Mountain, in Chester County.

The Third Zone or District of the Gneissic Rocks is confined to the belt of hills ranging from the Delaware below Easton to Reading on the Schuylkill, known as the South Mountains. This tract, prolonged from the Highlands of New Jersey, follows this range of hills to where they subside near the Schuylkill, the gneiss being flanked on the S.E. by the upper margin of the Mesozoic Red Sandstone, and on the N.W. by the Primal White Sandstone, and Auroral Limestone of the lower border of the Great Appalachian Valley. Within these general limits, the Gneissic rocks occupy, for the most part, the higher ridges and their slopes, while the Palæozoic strata repose in the included valleys, and at the northern base of the Chain.

CHAPTER I.

SOUTHERN ZONE OF GNEISS,

OR GNEISSIC ROCKS SOUTH OF THE MONTGOMERY AND CHESTER VALLEY.

Observing the prescribed order of description, we shall begin our account of these ancient metamorphic strata with the Southern district, or that south of the first limestone-valley. But in order to exhibit fully at the outset its structure and composition, it will be expedient to depart from our usual rule of tracing each tract from E. to W., and begin in the middle, where the belt is broadest and most fully developed. Here we have the benefit of the fine natural section and series of artificial exposures furnished by the River Schuylkill.

Boundaries.—This most southern belt of our crystalline strata makes its first appearance at a spot in New Jersey, about six miles N.E. of Trenton, where it emerges from beneath the margin of the overlapping Mesozoic Red Sandstone. From thence it gradually expands in its course south-westward, keeping the southern border of Pennsylvania to Delaware and Maryland.

Its lower or south-eastern margin crosses the Delaware River a short distance below the bridge at Trenton, and passes by Bristol, Philadelphia, Chester, and Wilmington, being separated from the river by a narrow strip of Diluvial and Alluvial deposits, which only in a few places exceed one mile in width. The northern boundary, commencing at the same point in New Jersey, crosses the Delaware about a mile and a half above Trenton, and ranges in a somewhat undulating line to Sandy Creek, about a mile E. of the Wissahickon.

W. of the Wissahickon, the northern edge of this zone of the gneiss ranges just S. of Barren Hill; crosses the Schuylkill a little below Spring Mill, passes about a mile and a half S. of the Paoli, and terminates near Boardsley's Run of the West Branch of the Brandywine, and not far from the Chester County Poor-House. W. of the Brandywine, the gneissic rocks sink under the altered Primal strata, in a succession of anticlinal fingers, on slender promontories, the boundaries of which will be given when we come to trace their distribution in detail.

DETAILS OF THE SOUTHERN GNEISSIC DISTRICT.

*Gneissic Rocks of the Valley of the Schuylkill, between Philadelphia and Spring Mill.**—Commencing at Fairmount on the Schuylkill, and following the E. Bank of the river in a general north-westerly direction, our geological section intersects the strata nearly at right angles to their strike. It presents the formation under a great variety of features and of composition; the several kinds of gneiss alternating in considerable frequency with each other. It is not possible to divide the whole of this broad belt of Gneissic country, and the Palæozoic belt of Montgomery and Chester, into any very sharply-defined subordinate ranges, for the many differently constituted bands of the crystalline rocks either so fade into each other, or are of such limited

* The reader should here consult the Geological Map and the Illustrative Sections of the Schuylkill and neighbouring valleys.

length, that to trace and map them in detail would be a work of herculean labour. The strata are too generally obscured by a deep covering of loose earth, largely derived from their disintegration, and the rocks themselves are too deeply rotted and softened by surface action, to permit that abundance of salient exposures which would be essential to the recognising and picturing, with minute exactness, of their innumerable local bands. Nevertheless, the whole of the gneissic system of the Schuylkill may be approximately and conveniently subdivided into the three large groups of strata, occupying, where they are intersected by the river, three broad Belts.

The first, or most southern general Division or group, may be approximately defined as extending from the lowest exposures on the river, or those near Gray's Ferry, to the upper end of Manayunk; *the second, or middle* Belt, extending from Manayunk past the Serpentine and Soapstone range to a line a little N. of the upper boundary of the County or City of Philadelphia; and *the third, or northern,* extending thence to the northern edge of the whole Gneiss formation, as it is overlaid and limited by the older Primal rocks in the vicinity of Spring Mill.

First Belt.—The southern or Philadelphian Belt contains the following chief descriptions of ordinary gneissic rock, with many sub-varieties. The most common or typical variety of all is a grey, bluish, rather finely-laminated triple mixture of quartz, felspar, and mica; the quartz, for the most part, white or transparent; the felspar usually white, and very generally somewhat chalky from incipient decomposition; and the mica, most commonly black or dark brown, and in small plates. This rock occasionally includes small insulated garnets.

The next most common species is a dark, bluish-grey, sometimes greenish-black gneiss, composed of hornblende and quartz, with sometimes a little felspar, the hornblende always greatly predominating. This rock is very usually fine-grained and thinly bedded, its fracture and structure being controlled by the general parallel crystallisation of the prevailing hornblende.

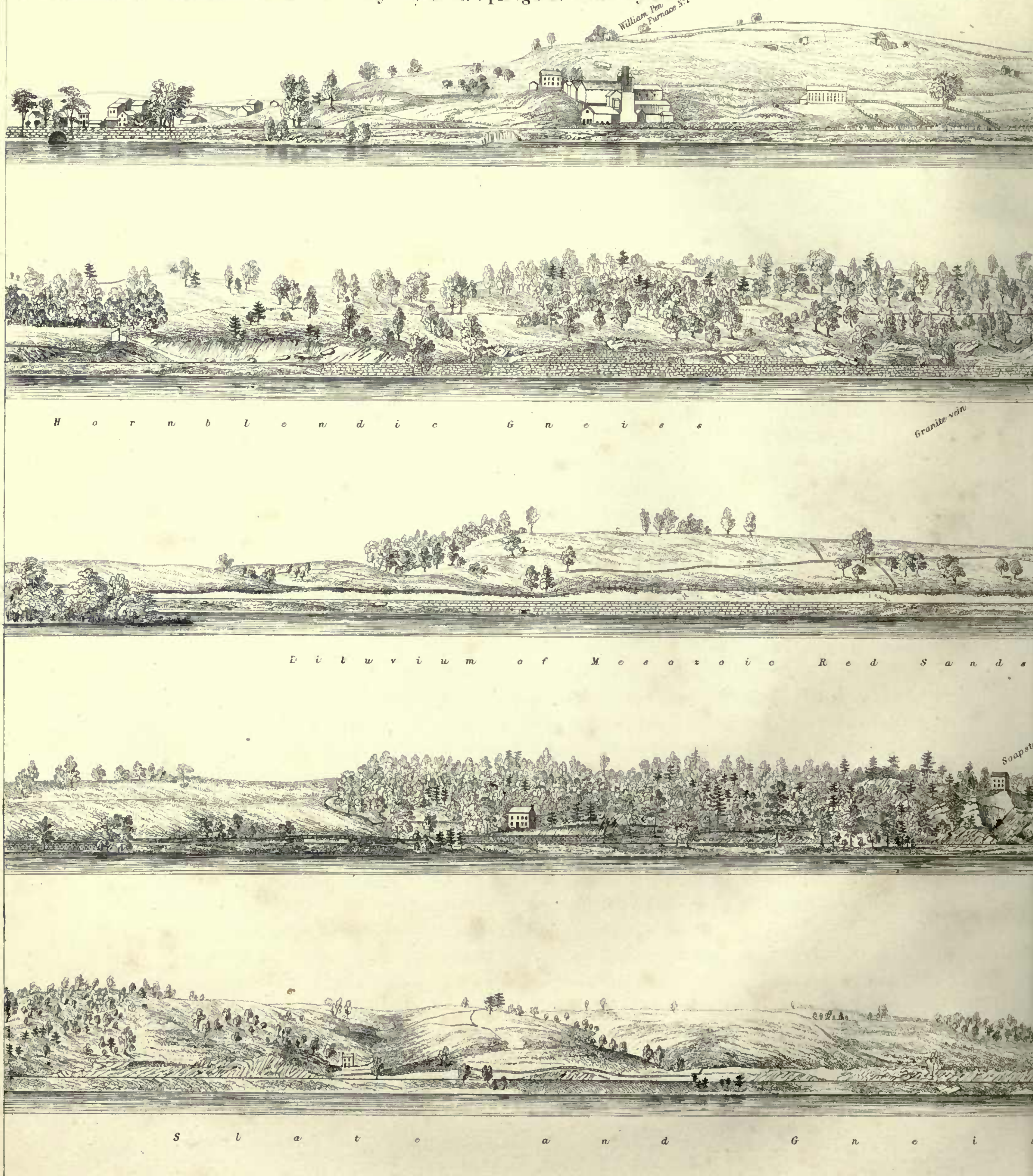
A third common variety of the gneiss of this group is a micaceous quartzose rock, generally of a light grey colour. Some beds of this species contain such a predominance of the crystalline quartz, in minute granular division, and such a subordinate amount of minutely disseminated mica, as to have a character of ordinary grey whetstone; but this species of the gneiss is much more abundant in the middle belt than in the southern one. A much coarser kind of grey micaceous gneiss, consisting of a predominance of rather large flakes of mica, with a subordinate quantity of felspar and quartz, occurs interstratified with all these other species, as a very usual transition variety between the standard grey gneiss and the highly micaceous kinds verging towards mica-slate.

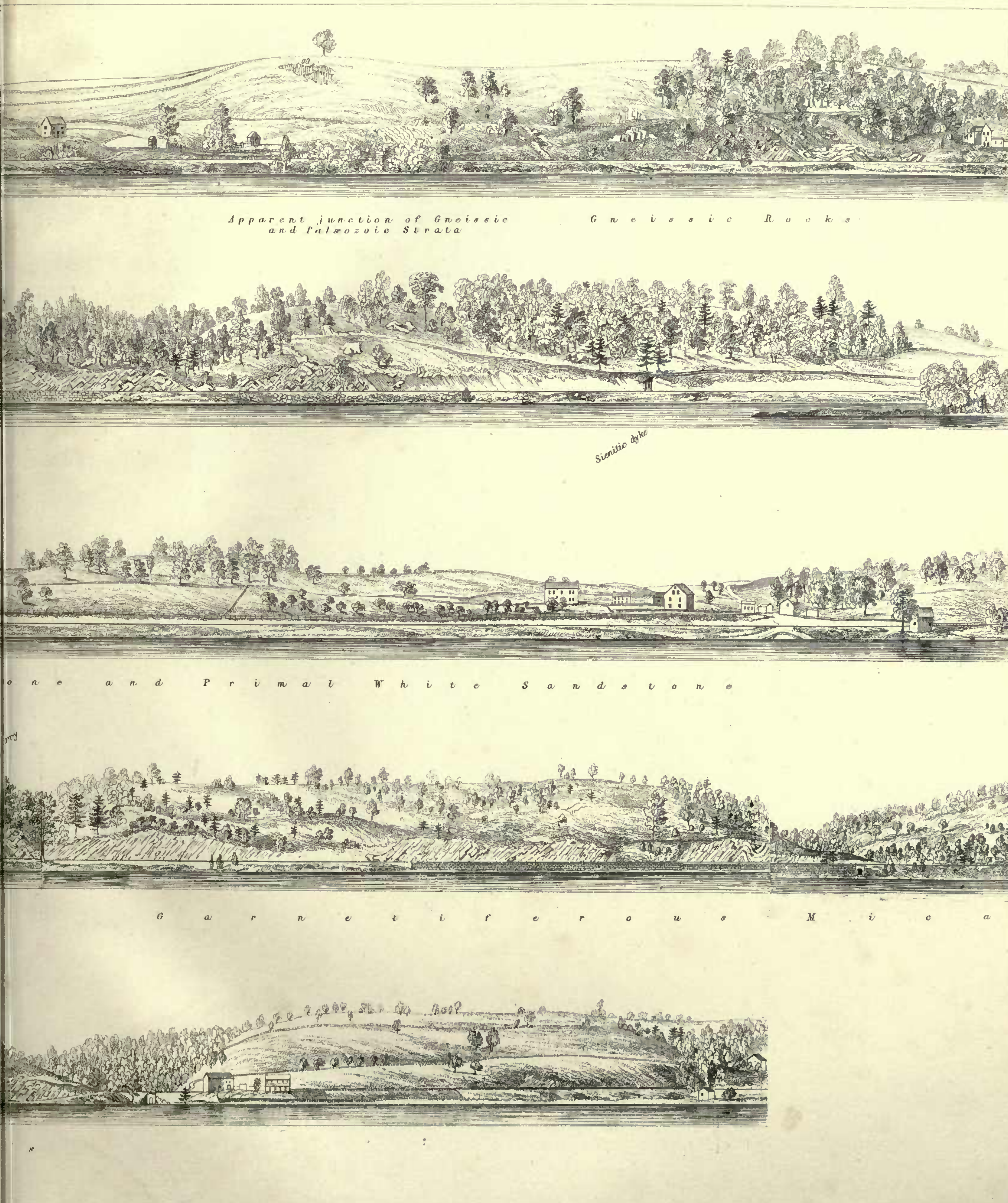
It is very usual to find the typical gneiss, of a threefold constitution, alternating with the hornblendic species, and both of these alternating with the quartzose micaceous variety. As a general fact, not without exceptions, however, the more micaceous the rock is, the greater is its abundance in insulated crystals of common garnet.

Interposed among the above varieties of true gneiss are beds, more or less thick, of kinds so abounding in mica as to be entitled to the designation of true mica-slate. This rock prevails in two or three outcrops, both above and below Columbia Bridge, and it may be stated generally, that the further north we advance across the southern division of the gneiss, the larger is the proportion of the more micaceous varieties of the ordinary gneiss, and the greater the frequency of these bands of mica-slate.

An interesting variety of the ordinary or more felspathic kind, is one containing large, more

Pictorial Section of East Bank of the Schuylkill from Spring Mill to Manayunk



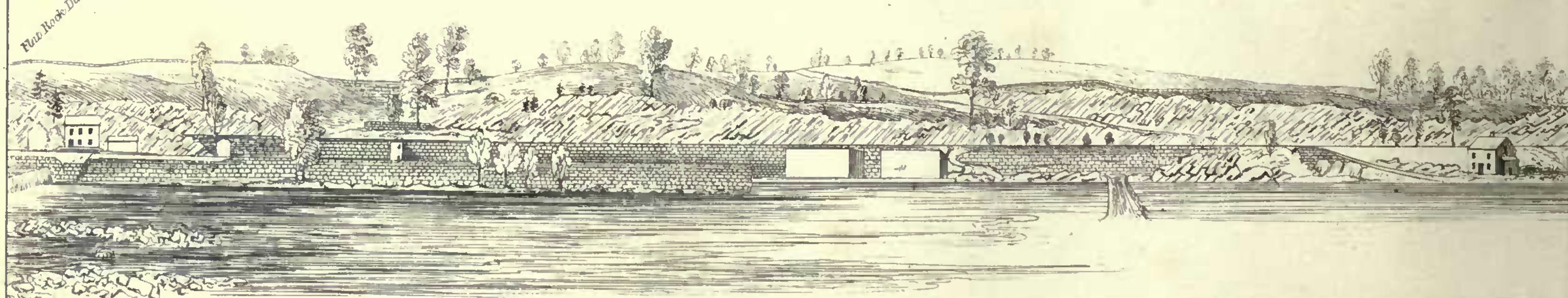


Engraved by W. & A. K. Johnston. Edinburgh.

Pictorial Section of East Bank of Schulkill – Continued.

Micaceous Gneiss, Mica Slate. Garnets. Quartzos

Mica Slate Granite Micaceous Quartzose G

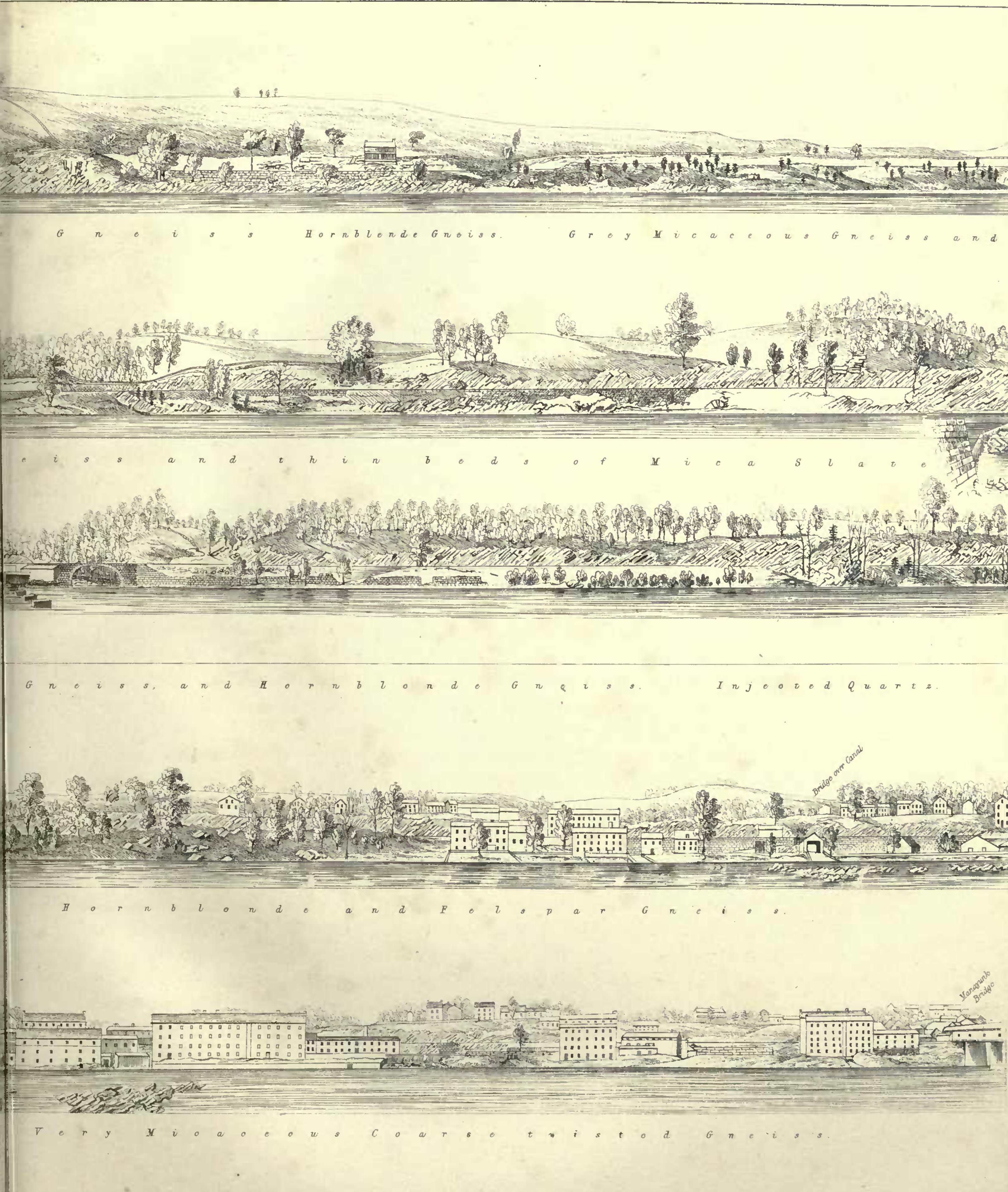


Coarse Gneiss. Contorted Garnetiferous Micaceou

Hornblende Gneiss

Manayun

Micaceous Garnetiferous and Quartzose Gneiss


Gneiss Hornblende Gneiss. Grey Micaceous Gneiss and
eiss and thin beds of Mica Slate
Gneiss, and Hornblende Gneiss. Injected Quartz.
Bridge over Canal
Hornblende and Felspar Gneiss.
Manayunk Bridge
Very Micaceous Coarse twisted Gneiss.

or less insulated, segregations of crystalline felspar, the longer axes of whose crystals lie generally parallel with the lamination of the rock. This variety may be designated a porphyritic gneiss, having that feature of an excess of crystalline felspar which is accepted by geologists as a distinctive character of the porphyritic rocks, and being, moreover, essentially similar to those well-known and beautiful granites which geologists agree to call Porphyritic.

A band of this porphyritic gneiss occurs at the Falls of Schuylkill, just below the Quarries, and ranges towards Nice-Town in one direction, and towards the Toll-gate, on the Lancaster Road, five miles W. of Philadelphia, in the other. Another outcrop of the same felspathic variety of the gneiss may be seen crossing the West Chester Plank-Road, just E. of Darby Creek.

The Gneiss rocks, especially the more felspathic varieties, exhibit throughout this southern belt an extensive disintegration, pervading them in some localities to a depth of many feet below the soil. When in this condition, the felspar is either wholly or partially converted into kaolin (or China earth), and softened; the mica is itself also sometimes decomposed, staining the mass, from the oxide of iron set free. Such is likewise the case with the hornblende, where this is an ingredient. To this susceptibility of decomposition under long-continued atmospheric agency, we must ascribe the great prevalence of mica in the soil of this region, and the general absence of superficial fragments and boulders of the gneiss, these having, in part at least, wasted into soil. By the slow but increasing disintegration of the felspar, a certain small portion of *potash* is constantly furnished to the soil to sustain its natural fertility, and the mica loosened from the rock becomes also a valuable ingredient, by giving it a peculiar spongy texture, admirably suiting it for the retention of moisture. A practical application of this rotted gneiss is occasionally made near Philadelphia, the loose materials of the rock being sifted, to procure a sand which is of remarkable sharpness, and well suited for the purposes of masonry.

Granite Veins.—In this southern zone of the gneiss formation occur numerous injections of true granite. These are for the most part narrow, obscure dykes, or more truly intrusive veins, penetrating and branching into the gneiss rocks, which are very generally contorted in their vicinity. Frequently these veins expire within the gneiss, only the larger ones having been injected with force enough to cut entirely through it. These granite dykes possess a remarkable general uniformity of composition and mineral character. The constituent minerals are felspar, quartz, and mica, all coarsely, independently, and confusedly crystallised. The predominant mineral is white felspar, and the next most abundant constituent is the quartz; the mica, indeed, being frequently almost wanting. The prevalence of felspar imparts to these veins a predominant whiteness, which usually enables them to be immediately recognised. It is likewise the cause of their generally very rotten condition, for throughout all this district the felspar and other easily decomposible minerals are, from some cause, universally and deeply decayed.

Unstratified or true Igneous Rocks.—Several rocks of the igneous class present themselves in the district before us. Of these, one of the most frequently seen is a peculiar felspathic *syenite* in thick dykes, also a white coarse-grained *granite* composed of felspar and quartz, in tortuous and sometimes ramifying veins, and *greenstone* and other forms of *trap-rock* in dykes, and also quartz, chromiferous iron ore and other minerals, occurring singly or associated in the shape of elongated thin dykes or narrow veins. To these should, perhaps, be added some of the masses of *serpentine*, for the unstratified character of these last named is no longer doubtful.

Syenite.—Of the above-mentioned intrusive rocks, the most largely developed is the species which I have called a Felspathic Syenite. This is for the most part a confused crystalline mixture of translucent smoky felspar and quartz, with sometimes a little mica, and more rarely a small proportion of hornblende. The felspar frequently forms almost the entire mass of the rock, and is always the predominant ingredient. Where it occurs alone, the crystallisation is usually very coarse and perfect. In the central portions of the dykes or beds, this rock presents few or no traces of any parallelism in its internal structure, much less any genuine stratification, but upon the sides where it approaches contact with the strata of gneiss enclosing it, an imperfect stratification is discernible. This feature is only such, however, as belongs to many dykes of genuine igneous granite, and by no means indicates it to appertain to the stratified metamorphic class. The rock before us is well adapted to certain purposes of architecture, being much more cohesive than the ordinary gneiss rock of the region, and less liable to disintegration under atmospheric action. Its chief localities are in the south part of Delaware County, from whence it passes southwestward into the State of Delaware, the dykes augmenting in frequency and size as we trace them in that direction. This rock has been extensively employed in the construction of the Delaware breakwater. The largest quarries of it are on Naaman's, Brandywine, and Christiana creeks, in the State of Delaware. The localities of the more important trappean and other dykes will be mentioned in another place.

Trap Dykes.—Where the road from Davisville to Huntingdon intersects the county line, there is an extensive *trap dyke* running nearly E. and W. in a straight line for three miles. The gneiss in its vicinity assumes very much the character of a syenite, and some of it might be useful as a building-stone.

The River Schuylkill presents a series of excellent exposures of the different divisions of the gneissic belt, from Philadelphia to Spring Mill. The general structure of this part of the region is exhibited in No. III. of the larger sections.

At Fairmount, near Philadelphia, the gneiss projects above the Diluvium, and is quarried to some extent in this vicinity, and also on the west bank of the river in several places. The grain or lamination of the rock is exceedingly contorted, implying the occurrence, at some period, of an immense compressing force. In all the quarries from Fairmount to the Falls of the Schuylkill, the rock is intersected by numerous cross joints, which appear, until closely examined, to represent its divisional plains or true stratification, and which, at Fairmount, are nearly horizontal. These joints divide the mass into blocks of convenient shape and dimensions, and when they dip in the proper direction, greatly facilitate the operations of the quarry. The belt of felspathic gneiss which passes Philadelphia is well developed on Darby Creek, Crum Creek, Ridley Creek, Chester Creek, and the other adjacent streams. On nearly all of these it has long been wrought, supplying Philadelphia and other places with a large amount of very excellent working-stone, and material for the foundations of houses, and for other purposes. At the Falls of the Schuylkill there is a large quarry of very excellent gneiss of a light grey aspect, which has long contributed its supply of good building-material to Philadelphia. In this quarry there is a vein of large-grained granite, with red felspar; the strata dip to the N.W.

Falls of Schuylkill Quarry.—The quarries at this locality expose the thick-bedded variety of gneiss, consisting of felspar, quartz, and black mica, with an occasional sprinkling of solitary crystals of garnet. The felspar and garnets show a tendency, especially in the upper layers, to partial decomposition. The stratum is traversed by numerous great joints, running approximately N. and S. The direction of the dip is about 15°—20° to N. 20° E. It tends to quarry in large irregular trapezoidal blocks. The mica in this rock is in minute scales, and small in quantity in proportion to the quartz and felspar. The *lower quarry* exposes a massive gneiss, of alternating mica and felspar bands, with tendency to a porphyritic structure from excess of felspar.

Second or Middle Belt.—The middle zone of the Gneiss of Southern Pennsylvania, as it crosses the Schuylkill, consists of an alternation of four principal varieties. Perhaps the most abundant of these is a very micaceous species of the ternary or mica quartz and felspar rock, holding garnets in greater or less profusion. A very common feature in this rock is a wavy or minutely undulated lamination, arising apparently from a contorted or wavy structure in the coarsely crystallised mica, its predominant mineral. This would seem to proceed from the interference of the innumerable planes of cleavage, or—what is the same thing—of crystalline lamination with the original planes of deposition of the strata. The twisted form of the flakes of mica is frequently seen to be due to the displacing effect of grains, or crystalline bunches of included quartz. It would seem as if these minerals had crystallised or segregated, from their parent sedimentary materials, under a conflict of forces, the newly-awakened crystallising energies being not always parallel to the original bedding of the deposit, but more frequently oblique to it.

Perhaps the next most common subdivision of the gneiss of this middle tract is a variety consisting almost exclusively of the above-described wavy mica. This rock graduates into the more micaceous sorts of gneiss, by containing a less or greater mixture of finely-granulated crystalline quartz, felspar, and hornblende. The southern half of the gneissic zone before us is characterised, on the Schuylkill and the Wissahickon, by containing an alternation of the above two varieties of micaceous gneiss or mica-slate, with beds of hornblendic gneiss—the last-named rock being, from its thin lamination, sometimes entitled to the name of Hornblende Slate. The northern half of the zone consists largely of a fourth variety of the more schistose class of the gneissic rocks. This is a grey fine-grained binary mixture of granular quartz and minutely crystallised scales of mica, the quartz being the prevailing element. It is a species of whetstone, and some of the more quartzose bands would furnish masses well suited for employment as whetstones for scythes. A very common, indeed a characteristic feature of this quite remarkable and extensive division of the micaceous gneiss group, consists in its peculiar fracture ; the rock breaking into long narrow chunks, comparatively smooth on their sides, but excessively ragged on their ends ; a style of fracture strongly resembling that of half-rotted fibrous wood. This peculiar rock is in greatest force towards the northern side of the middle gneissic belt, or between the serpentine and steatite, and the hard felspathic gneiss of the southern margin of the third or Northern Gneissic Belt. It is interstratified towards its southern side, with more or less frequent and thick bodies of the other variety of mica-slate, possessing the mica in large and twisted scales, with an abundance of garnets. On its northern side it alternates to some extent with a greenish talcose slate, or, what is the same thing, the talc in this quarter replaces the mica in whole or in part in certain divisions of the group.

It is here that we meet with the interesting belt of Steatite and Serpentine, which extends from E. of the Wissahickon on the brow of Chestnut Hill, across the Schuylkill to Mill Creek, beyond Merion Square. Viewing the steatite as a stratified rock of the mica-slate group, we may reasonably regard it as having been metamorphosed to its present composition and structure, by infusion of magnesian matter from the dyke of intrusive Serpentine which everywhere adjoins it.

Wissahickon Creek Section, comprising the Talc-Slate, Steatite, and Serpentine.—This section, intended to illustrate the Middle Belt, commences at the most northern exposure of the mica-slate S. of Thorpe's Paper-Mill. The rock is a mica-slate, exceedingly full of garnets. Besides the mica, which is the principal constituent, and the garnets, it contains a little minutely disseminated quartz, but not much. The dip is 80° to S. The mica is everywhere more or less minutely wavy, and in the very micaceous kinds it is coarsely crystallised and remarkably waved. It weathers a ferruginous brown.

The exposure of talc-slate, steatite, and serpentine, commences opposite the bridge over Wissahickon Creek, near Thorpe's Mill. The first rock which here succeeds the garnetiferous mica-slate above described, is a stratum of green talcose slate, estimated to be 40 feet thick ; this dips about 70° to N., about 20″ W. Reposing upon it at the same angle is the Steatite Group, which is an alternation of talc-slate and talcose steatite ; the former material apparently predominating. This occupies an estimated breadth or thickness of 120 to 140 feet. In the northern half of this group the talcose chloritic beds contain numerous octahedral crystals of oxide of iron.

Next in order N., and adjoining the Talc-Slate and Steatite, is the Dyke, or Bed of mixed Serpentine and Steatite. The thickness of this is not great, apparently not more than from 12 to 20 feet.

A steatitic Talc-slate adjoins the Serpentine on the N., extending for 30 feet.

Then succeeds a Garnetiferous Mica-slate, dipping about 85° to N., 20° W., quite garnetiferous, precisely similar to that below this. It dips as do the others, and extends for 75 feet.

This is succeeded by a close-grained Quartz-slate or Scythe-stone, the thickness of which is about 100 feet.

Following this is the ordinary very garnetiferous Mica-slate—mica in large flakes, and crinkled. This bed has a thickness of 50 feet.

Next in order, extending for 500 feet, is a group of beds composed chiefly of a hard Quartzose Mica-slate, or thin-bedded Quartzose Gneiss, including alternating thin beds of the ordinary garnetiferous mica-slate.

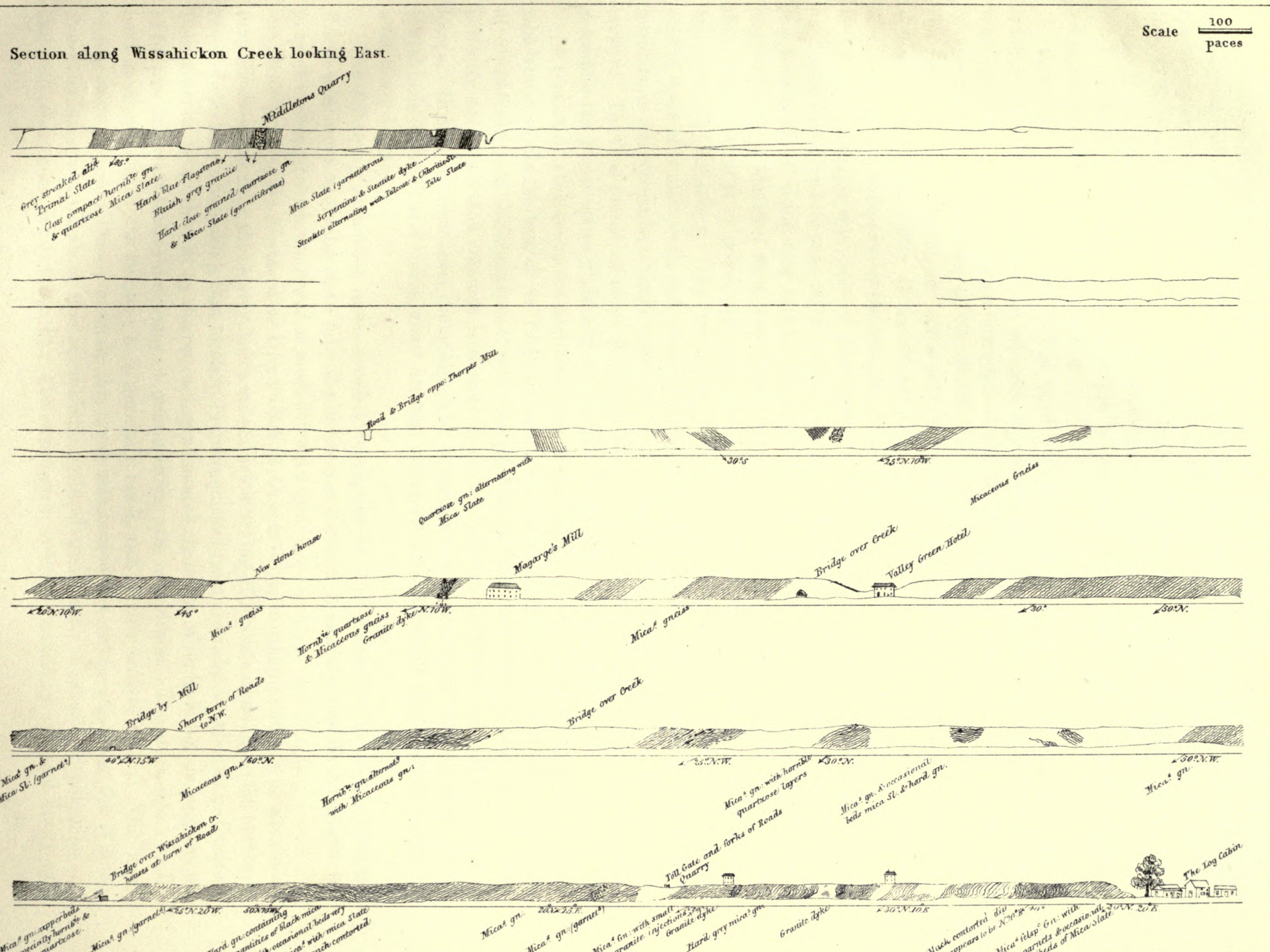
This brings us to a bold dyke of Bluish-grey Granite, from 50 to 60 feet in width.

Then succeeds a hard Blue Micaceous Quartzose Gneiss or thin-bedded Flagstone. This alternates with the more rough mica-slate ; it has a thickness of about 200 feet. On the N. edge of the Quarry it seems to dip S. 85°, but towards its northern limit its dip is about 85° to N.

Succeeding this rock is a belt of close Hornblendic Gneiss and Quartzose Mica-slate, having a thickness of 200 feet, its northern limit coinciding with a marked depression in the hills. These are the uppermost or terminal beds of the great gneissic formation. A spring of remarkably pure well-aerated water occurs in the Flagstone Group, a little N. of the Granite Quarry.

Passing the depression in the hill, we enter immediately upon the Primal Older Slates in their usual metamorphic condition, with characteristic white streaks of imperfectly crystallised felspar and dark hornblendic mineral, and with the roundish specks of semi-crystallised felspar. One band in this formation is excessively hornblendic, very ferruginous, and may possibly include some workable iron ore. These rocks possess precisely the type which they exhibit on the Schuylkill. Their thickness on the Wissahickon Creek cannot be less than 300 feet ; dip about N. 20° W.

Section along Wissahickon Creek looking East.



W. & A. K. Johnston, Edinburgh.

No outcrop of the Barren-Hill White Felspar Rock could be detected at the base of the hill. That the Barren Hill opposite this point has an anticlinal structure, seems evident from the fact that the overlying limestone occurs on the S. slope of the ridge, close to the turnpike-gate on the city line, at the intersection of the Germantown and Perkiomen Turnpikes. Good brown iron ore is found in the Little Valley between the main hills of Gneiss and the Barren-Hill Ridge.

I am inclined to infer, that upon the Wissahickon Creek this highest group occupies a narrower belt than upon the Schuylkill.

Third or Northern Belt.—The third and most northern of the divisions into which we have found it convenient to separate the Gneiss of the Schuylkill district, extends from the somewhat abrupt cessation, or edge of the above-described micaceous belt, to the base of the Primal altered slates of the South Valley Hill, at Spring Mill. This zone is here, at the river, not more than about half a mile in breadth; and what is curious, it runs to a point, before reaching the Valley of the Wissahickon, only two and a half miles to the eastward, being overlapped obliquely by the margin of the Palæozoic rocks. From its tapered point near the Ridge Turnpike, this zone of hard gneiss expands regularly in its course westward, until at Darby Creek, and beyond it, or in the vicinity of the Delaware and Chester County line, it has a breadth of about four miles. The materials constituting this northern tract are very similar to, if not identical with, those which compose the southern or Philadelphian one. If they differ from that, it is by possessing a less proportion of the more micaceous varieties of gneiss, and almost no mica-slate. The prevailing varieties in this tract are, first, a massive felspathic gneiss, some of it micaceous, and some of it like a stratified syenite; and, secondly, a dark hard hornblende felspar gneiss, thinly laminated and strongly striped, when viewed in transverse section. The first-named, or more felspathic kind, is in some beds porphyroidal, and strongly resembles the gneiss above Philadelphia, and that at the Falls of Schuylkill.

A remarkable feature in the northern or uppermost bands of gneiss on the Schuylkill, or those which next adjoin the base of the Primal series, is the possession of a less than usual completeness of crystallisation in the constituent minerals, the felspar, more especially, appearing to be less perfectly developed than common, and more in the condition of roundish or lenticular segregated lumps. In this circumstance, the gneiss here approximates somewhat to the structure of the lowest beds of the Primal series, which are also porphyroidal, but exhibit their metamorphism in a far lower degree.

The following somewhat more detailed description of this Northern Belt of the Gneissic Rocks will serve to exhibit more fully the differences between it and the middle Zone, and its general agreement with the lower or more southern one.

Description of the Northern or Upper Belt of Gneiss.—The northernmost belt of gneiss, or that commencing near the Quarry, half a mile S. below Spring Mill, and extending to the northern brow of the hills overlooking that locality, is distinguished from the next division of the Gneissic Formation to the south of it, by the prevailingly massive character of its bedding, its large excess of felspar, and comparative deficiency of quartz, mica, and hornblende. The mica seems to be next in abundance to the felspar; it is generally black, and in very minute scales. The hornblende element predominates most in the upper members of the group adjoining the William Penn Furnaces, where beds of true hornblendic gneiss alternate with micaceous felspathic layers, and with others more purely felspathic. This entire group contrasts strikingly with that next south of it, in the total absence of garnets, and of that excess of mica, or of mica and quartz, which so generally characterises the garnetiferous varieties. From the massiveness of many of its beds, and the regular parallelism of its structure, this rock is admirably adapted for quarrying; the less contorted and disturbed parts of the formation being fit to afford an abundance of noble blocks of building-material of almost any dimensions. Two sets of joints traverse the strata, one perpendicular to the horizon, but nearly at right angles to the strike, no matter what the inclination of the dip; the other approximately coincident with the strike, and for the most part nearly perpendicular to the plane of stratification.

This rock displays a marked gradation of abatement, as we ascend from the lower to the upper members of the group, in the extent of segregation or crystalline separation of its constituent minerals. These, in the inferior beds, are almost invariably the felspar and mica, especially in separate parallel laminæ; and where the felspar is in excess, it occurs in large porphyroidal crystals. But in the middle and superior portions, while the general parallelism of the lamination is still retained, the laminæ are finer and more commingled. The several mineral constituents are less coarsely crystallised, and any isolated felspar has the form of lenticular or ovoidal knots, showing a lower, less advanced, stage of segregation. It would seem as if these highest members of the whole gneiss formation have experienced a less perfect and thorough metamorphism than the middle and lower masses.

Structure of the Upper or Northern Belt of Gneiss.—Near the bend of the Schuylkill, the lower strata of this upper group, in a bluff hill one-third of a mile below the William Penn Furnaces, displays a true anticlinal flexure, and it is here, just on the anticlinal axis, that the more northern of two considerable veins of granite intersect these strata. From this axis northward for 350 feet, the beds dip very regularly at angles declining from 55° to 40°, towards N. 20° W.; and for the next 800 feet their inclination is so gentle, that they may be described as horizontal. Such dip as they do possess is from the river towards the N.E. At the limit here mentioned, they exhibit a distinctly marked synclinal structure, rising with a gradually increasing inclination for the next 300 feet, and then immediately displaying for the following 600 feet across their strike a succession of remarkable contortions, presenting, on a small scale, several beautiful anticlinal and synclinal folds. This brings us to within some 200 feet of William Penn Furnace, No. 2. Here the contortions appear to terminate; and with the exception of a few very subordinate twists in the bedding, the strata stand almost perpendicularly throughout the next 1400 feet. This brings us to the northernmost limit of the whole Gneiss formation, or to a line about 1400 feet N. of the Old William Penn Furnace, No. 1. It is possible that one or two plications may exist in this space; but with one exception, which is at the northern end of the Upper Furnace (No. 1), the prevailing dip is nowhere less than about 80° to either the N. or S.

As an argument for the general unconformity of the Lower Primal Rocks to the Upper Gneissic group, I would call attention to the folded and contorted condition of the latter, and the very uniform, nearly vertical, dip of the first-mentioned. Another even more cogent reason for assuming such unconformity is the striking contrast which prevails in the law of flexure, of the two formations. The undulations of the gneiss do not belong to the Appalachian system of south-east-dipping axes planes, but exhibit a wholly different character, being either minute and local contortions, or wide gentle undulations, with comparatively moderate dips, which are for the most part to the N., and not, as in the other system, to the S.

Subdivisions and Details of the Northern Belt of Gneiss on the Schuylkill.—Commencing at the point below the Granite Quarry, S. of Spring Mills, at about 100 feet S. of the end of the long tangent in the Norristown Railroad, occurs the most northern good exposure on the side of the railroad. It begins with a small injection of pinkish granite composed of felspar and quartz.

Immediately adjoining the granite on the N. side, we find a variety of massive gneiss, consisting of rather coarsely crystallised felspar, quartz, and hornblende, with some mica. Certain bands of it tend to the porphyroidal structure, from excess of felspar. It is evenly bedded, and shows the parallel lamination of gneiss, but this is not minute or very continuous. It dips about 80° to N. 20° W. A similar massive gneiss appears to occupy the hill on the opposite side of the river, at the cuts in the Reading Railroad.

About 160 feet N. of the first dyke is a second vein of granite, or more properly a syenite, producing, on the gneiss in contact with it and S. of it, a S. dip of 70°. This syenite is composed, chiefly, of coarsely crystallised felspar, both pinkish and white ; it holds a much less proportion of quartz, and a considerable amount of large specks of imperfectly crystallised or finely granular hornblende. The injection is about 10 feet thick.

Succeeding the dyke of syenite, is a repetition of the kind of gneiss occurring to the southward, massively bedded, porphyroidal in many of its layers, of a bluish-grey colour, and consisting, for the most part of a triple mixture of felspar, quartz, and mica, and occasionally some hornblende—the felspar frequently appearing in large insulated blotches. This rock is now extensively quarried ; it occupies the bold point of the hill, causing a bend in the river. From the vein of syenite, for 250 feet across the strike, it dips very evenly at an angle of 45° or 50° to N. 20° W. But at that distance the dip changes pretty suddenly to a very small angle. On the side towards the syenite it is penetrated by a few injections of granite. It would thus seem that there is here a true anticlinal flexure in the gneiss—a large vein of syenite being protruded very nearly in the axis. The slight northward dip is succeeded at about 900 feet from the Quarry by a gentle dip to the S.

Some 387 feet N. of the Small Quarry, at the S. end of the New Furnace (William Penn Furnace, No. 2), the rock is seen in a cut made for pumps ; the dip is almost perpendicular, about 87° S. It is a good exposure of a quite peculiar gneiss, massive, dark-blue, streaked, and lenticularly spotted white. It consists chiefly of felspar and dark-blue mica, in alternate slightly wavy bands or laminæ, with lenticular concretions, or crystallisations of pinkish-white felspar. Some of the beds are porphyroidal, from abundance of lumps of felspar, others minutely or closely laminated in delicate parallel, slightly wavy, bluish-black and pinkish-white streaks, produced by the two predominant minerals. This rock contains some quartz, and occasionally some hornblende. Its vertically dipping beds support the large New Iron Furnace, No. 2.

At the N. end of the New Furnace is a felspathic micaceous gneiss, somewhat minutely banded, without the lenticular crystallisations of felspar. 266 feet from the N. end of the New Furnace is a trap-dyke, very hornblendic, about 8 feet thick.

About 421 feet N. of the north end of the New Furnace is the same kind of gneiss, minutely streaked or laminated, some beds still containing lenticular segregations of felspar, but these fewer and smaller, the whole rock more minutely and evenly laminated, and more closely resembling an altered argillaceous sandstone, yet still claiming the appellation of a gneiss. The felspar has a mealy chalky aspect on the weathered surfaces.

About 100 feet N. of the north end of the Old Furnace, No. 1, is an exposure of a felspathic micaceous gneiss, which continues for 170 feet. At the north end of this furnace the dip is 60°, but 100 feet farther on it is 85°.

Nearly 330 feet N. of the north end of No. 1 Furnace, there is a ledge of a somewhat different rock, with almost perpendicular and regular bedding. Decidedly less gneissic in its crystallisation, it has lenticular lumps of felspathic mineral, and is finely streaked ; the whole has an earthy sedimentary aspect, and the felspathic specks and concretions are rounder than in the true gneiss; the strike of the rock is nearly S. 70° W., or parallel with the prevailing strike of the genuine gneiss; to the southward its course is such as to range straight for the shore of the river at the Ferry House, opposite Spring Mill, and it must range thence along the north base of the belt of hills bounding the river, between the Ferry House and Merion Furnace, opposite Conshohocken. This rock has a more earthy and less crystalline aspect. I incline at present to regard it as the lowermost member of our Secondary or Palæozoic system of strata. If it be really such, it is not here locally separated from the gneiss beneath it, by any marked unconformity in respect to either their strike or dip, but the two sets of rocks are contrasted in a very marked manner, both in their external aspects and their mineral composition. The passage from one into the other is so abrupt as regards their composition and crystallisation, as to require us to place them in wholly different systems. The visible thickness of the vertically-dipping beds of this upper doubtful group is about 100 feet. This stratum forms the N. point and face of the hill, immediately S. of the Spring-Mill Valley.

Limits of the three Belts of Gneiss of the Southern Gneissic District, more precisely defined.— It is not possible to trace, at least at present, with close precision, the boundaries eastward and westward which separate the southern and northern belts of harder gneiss, from the middle tract of softer, or more micaceous strata ; but their approximate limits may be indicated somewhat as follows :—

Limits of the Southern Belt.—The Southern, or Philadelphia Belt, can be traced from the Delaware, below Trenton, to the Neshaminy, constituting the whole of the gneiss S. of the southern edge of the red sandstone. West of the Neshaminy, its northern border, or that which separates it from the micaceous middle belt, leaves the southern trough of Primal white sandstone, and, trending south-westward, passes between Shoemaker Town and Mill Town, and crosses the Schuylkill near the northern side of Manayunk. To the S.W. of the Schuylkill the limit is less precise, partly from a deficiency of exposures of the rocks, and partly—perhaps chiefly—from the existence of a succession of undulations, which may cause a repetition of outcrops, or separate belts of the two divisions of the strata. On the Brandywine, the northern limit of the more massive gneiss would appear to be somewhere N. of Chadd's Ford. It would seem that, after crossing the Brandywine, the rocks of this group run forward for several miles, into Chester County, and through the northern side of Delaware into Maryland, in a succession of gradually contracting ranges or slender fingers, the more northern of which terminate in the neighbourhood of the Redclay and Whiteclay Creeks, while the middle ones extend forward to cross the Little Elk Creek, and to pass to the south of the eastern end of the great Southern Belt of the Serpentine. It is very obvious, from the structure of this zone on the Brandywine, from Chadd's Ford, southward, and through the country to the west of that stream, that the gneiss is here undulated in a series of wide anticlinal waves. This is indicated, not only in the alternately N. and S. dips of the strata on the Brandywine, but in the occurrence of those several synclinal troughs of Primal and Auroral palæozoic rocks, which in the south-eastern corner of Chester County, and the north-eastern corner of the State of Delaware, are folded in between the uplifts of the gneiss. Besides these anticlinal fingers, this southern gneissic belt sends forward to the S.W. a long unbroken zone or line of outcrop, through Northern Delaware and Cecil County, Maryland, to cross the Susquehanna River between a point some two miles below the Pennsylvania State line and Havre-de-Grace. This is a grey granitoid gneiss, composed largely of quartz and felspar, and occurs on the Susquehanna in very massive beds.

Limits of the Mica Slate or Middle Gneissic Belt.—Viewing the middle micaceous belt as terminating eastward, somewhere in the neighbourhood of the Neshaminy, and S. of Edge Hill on the southern ridge of Primal sandstone, we can define its northern limit to be formed by that outcrop of Primal rocks passing Moretown and Chestnut Hill, to a point a little W. of the Wissahickon, at which latter place the mica-slate seems to leave the belt of Primal rocks, and to be bounded thenceforward on its north-western side by the south-eastern margin of the northern tract of older felspathic gneiss. Thus limited, it crosses the Schuylkill, as already defined, about one mile S.E. of Spring Mill. From the Schuylkill the line of contact of the two groups, pursuing first a course somewhat W. of S.W., passes through the eastern corner of Haddon Township, and the lower edge of Newtown, to take a range somewhat more to the W., coincident nearly with the north-western edge of Delaware County. It then proceeds through Westtown, in Chester County, and crosses the Brandywine somewhere within a mile below the E. and W. branches of the junction of that stream. East of Unionville the tract of hard felspathic and hornblendic gneiss, to the N. of the more micaceous gneiss, appears to run to a point, and here, therefore, the common boundary of the two groups re-curves rapidly backward towards the N.E. Whether the rocks bounding this belt of harder gneiss, W. of the Brandywine, appertain all of them to the ancient Gneissic slate formation, or whether they are not in reality the lower Primal slates under a highly metamorphic and crystalline condition, is a question which remains open to future research ; but I incline to the belief that, within the general synclinal trough of the micaceous gneiss, where the Brandywine intersects it, we shall ultimately discover smaller synclinal waves, containing unconformable troughs of those older Primal slates. The western general limit of the middle gneissic belt may be vaguely defined, then, as occurring somewhere near the Brandywine, across which it is probable there extend some narrow anticlinal fingers, expiring, like those of the southern harder gneiss, under the overlapping, very undulating, margin of the altered Primal series. Whether, indeed, there may not occur, even in the more central tracts of this micaceous zone, between the Schuylkill and the Brandywine, some small insulated troughs of the Primal older slates, is a point which likewise remains for future investigation.

Limits of the Northern Belt of the Southern Gneissic District.—We have just defined, in a general way, the southern boundary of this northern tract of gneiss, and it remains to describe now its northern edge, or that which separates it from the long continuous belt of Primal talcose older slates which border it on the N. From a little W. of the Wissahickon, where this northern tract of gneiss seems to emerge from under the Edge Hill trough of Primal strata, the common limit of the gneiss and talcose slate can be readily traced along the northern brow of the Chestnut Hill range, to the Schuylkill just below Spring Mill. West of the Schuylkill, the line of contact of the older Primal, with the Gneissic strata ranges along the brow of the range of hills overlooking the river, and thence through the summit of this ridge, as it borders the limestone valley of Merion Furnace. It thus passes G. W. Fisher's, and P. Pechin's, and W^{m}. Morgan's, N.E. of Morgan's Corner. Thence its course takes it about half a mile S. of the Spread Eagle Tavern. On the back road from the Paoli to the Spread Eagle, S. of the turnpike road, we find the limit of the two formations, about one-third of a mile E. of the cross-road leading from Reeseville to the Leopard Inn, a dyke of close-grained bluish trap-rock occurring a little N. of the line of junction. Here the older rock is a dark bluish grey felspathic micaceous gneiss, very similar to that S.E. of Spring Mill on the Schuylkill. In this vicinity, further eastward, the gneiss is very quartzose and massive. It dips 85°, to N. 10° E. In the deepest of the railroad cuts, near the Toll-gate, W. of Morgan's Corner, the rock is a massive granitic gneiss, of greenish felspar, white and garnet-coloured quartz, and brown mica. These varieties are here cited, for the purpose of comparison with the very different kinds of gneiss, which we will presently find to prevail in contact with the Primal slates further westward. Tracing the edge of the gneiss, it may be seen to pass about one mile and a half S.E. of the Paoli, or half a mile N.W. of the Leopard Inn, on the Darby Road. Here the rock is a more hornblendic gneiss than further eastward, and the change from this hard material, to the softer talcose micaceous Primal slates, is plainly visible in the transition from a somewhat uneven surface to one of a lower level, having smoother outlines and softer undulations. Our line now crosses Crum Creek, near Mavis's Grist Mill; and here the gneiss is in close proximity to the southern margin of the long belt of stratified serpentine, which originates in the talcose primal slates, about one mile S.E. of the Paoli, and more than one-fourth of a mile N. of the gneiss at that point. From Crum Creek, where a very hornblendic gneiss commences and ranges for many miles south-westward, its northern or north-western edge, coincident nearly with the southern border of the serpentine as far as Taylor's Run, passes about one mile N. of Sugartown, and the same distance N.W. of West Chester. Following the southern side of the valley of Taylor's Run, till it approaches the Brandywine, it crosses this stream below Taylor's Ford, and preserves its course westward to the vicinity of Marshallton, keeping near the road leading from West Chester to that village. In the vicinity of Marshallton and Trembleville this line seems to terminate, or to deflect rapidly southward; for the north-western, or here, western boundary of the true gneiss, appears not to reach as far to the westward as the village of Unionville, in East Marlborough Township.

Of the Geological Structure of the Gneissic Region of the Schuylkill—(*See the Section.*)—A remarkable feature in the structure of the whole southern gneissic district, is the prevalence of a northward dip in the strata. This inclination prevails along the Schuylkill, with very few local and trivial exceptions, throughout all the three great subdivisions of the zone of gneiss, until we approach the upper or northern side of the third or northern belt. There the rocks for the first time, for any considerable width of outcrop, are contorted, folded, and lifted into a generally almost perpendicular dip. The ordinary or average angle of inclination of the strata may be stated to vary between 30° and 50°, and the prevailing point of the compass to which this dip is directed is somewhere between N. 20° E., and N. 30° E., though occasionally it is nearly N., and in one or two instances it is N.E. From Philadelphia, the whole way to the Wissahickon, there exists no interruption to this general northward dip, and not until we approach the lower edge of Manayunk is it much undulated or contorted, and even there the undulations are within very narrow limits, and produce very little reduction in our estimate of the thickness of the formation. At Fairmount the true dip of the rocks is very steep, approaching, indeed, to the vertical. The strata there are traversed by numerous conspicuous joints, presenting at a little distance a deceptive appearance of a nearly horizontal stratification, in thick and almost parallel beds ; but this is not to be confounded with the genuine stratification or grain of the rock, as marked by the structural distribution of its mica and other minerals.

Advancing northward, this steep inclination of the strata soon subsides, for along the shore of the river, from Lemon Hill to the Quarries below the Columbia Bridge, the ruling dip is in only one or two local spots steeper than 40°, or even than 30°. In the Quarries spoken of, it is in one or two places 50°, and even 70°. From the Columbia Bridge to the Wissahickon, and even beyond it, the rocks dip with remarkable steadiness at angles seldom lower than 20°, and seldom higher than 30°. Passing the Wissahickon, they begin to exhibit a series of local contortions, though but few of these contain a dip to the southward for more than a few yards. At two or three spots below Manayunk, the inclination is as steep as 50°, or even 70°, but at the town, and indeed as far up as the Sinnaminson Creek, a quite gentle slope prevails, the highest angle not exceeding 20° or 25°, excepting at one locality of very narrow contortions. Above the Sinnaminson, as far as the Greentree Run, the dips are a little more variable, and generally steeper, but nearly all are embraced between the angles of 30° and 50°. In this part of the section the strata are more waved in their dip, though never thrown out of their prevailing northward declination. Approaching and passing the Greentree Run, we find them through a space of nearly 300 feet in an almost perpendicular attitude ; they soon, however, resume their dominant northward dip; but from this point to the vicinity of the Soapstone Quarry, they present, for the first time, a succession of synclinal and anticlinal undulations. In this division of the section, the inclination of the strata—still to a large extent towards the north—is at all angles from 30° up to 70°. It is worthy of note here, that the steatite belt itself gives evidence of containing a synclinal wave in the dip ; for the talc-slates and mica-slates to the south of it, for several hundred yards, dip steadily towards the north, at an angle of about 30°, while those of the northern side of the Quarry show a steeper inclination to the south. Passing the Steatite Range, the northward dip is quickly resumed, and in this part of the Mica Slate Belt, both at the Schuylkill and on the Wissahickon, the slope is steeply towards the north.

Entering now that division of our section which belongs to the Northern Belt of harder Felspathic Gneiss, we encounter the most irregularly dipping or undulating portion of the whole gneissic zone. Approaching the Quarries of Blue Porphyroidal Gneiss, at the lower limit of this tract, we meet with a steeply-compressed anticlinal axis in the strata, the line of the axis marked by a strong dyke of syenitic granite. Here the south dips are 70°, and even steeper, while the north ones vary from 45° to 55°. Passing the Quarries, we immediately encounter a wide space of more than a fourth of a mile, in which the rocks are almost horizontal, and towards the northern edge of this we perceive an axis or turn in the dip, marking a broad, regular, synclinal trough or basin. From the northern edge of this trough, to the upper limit of the whole gneiss formation, past the William Penn Iron-Furnace, No. I., the gneiss is closely folded, and compressed into very steep, or nearly perpendicular dips, with numerous short plications.

If now we review these interesting features in the structure of this broad zone of gneiss, we can hardly resist the conclusion, that in the three belts passed over by our section, there are really but two groups of rocks, a lower and a higher, and that the entire zone, viewed broadly, constitutes but one wide synclinal wave or basin, the harder felspathic and hornblendic gneiss dipping northward, throughout the whole southern belt or outcrop, and reappearing in steep and multiplied contortions on the other side of the trough, and the upper or more micaceous group of rocks filling the synclinal centre of the trough, and compressed into the lesser foldings which it exhibits, by the lateral force of the wide crust undulation, within which it has been caught, and folded.

Of the Belt of Gneiss North of the Mooretown and Attleborough Range of Primal Sandstone.—Between the southern edge of the Middle Secondary or Mesozoic red sandstone formation, in Bucks and Montgomery counties, and the southern range of Primal white sandstone, extending from Edge Hill to Morrisville, there is a nearly continuous long and narrow tract of Gneiss rocks, which in their composition seem to be identical with those of the northern belt, west of the Schuylkill. Indeed, from the fact of this identity, and from their lying in the same line of strike, the rocks of the two tracts must be regarded as belonging to one continuous zone of strata, interrupted at the surface only by the basins of the older Palæozoic strata, which lie obliquely across the belt. It is not necessary to define it minutely in this place, further than to add to what has been now indicated, the statement, that at the western end of this area the gneiss runs forward in three points. The first and longest projecting finger of the belt is a contracting anticlinal outcrop, which is insulated from the middle finger by the narrow synclinal trough of Primal rocks, which passes the Pennypack Creek at Shelmire's Mill. From the Pennypack, where it is rather more than a mile wide, this promontory of the gneiss ranges contracting in width, between the southern foot of Edge Hill and the northern border of the Mooretown and Attleborough range of Primal strata, until, south of the village of Edge Hill, it has a breadth not exceeding one quarter of a mile. Within a mile to the W. of this place it runs to a point, being saddled by the Primal slates and white sandstones of Edge Hill, or the eastern extension of Barren Hill. This is evidently an anticlinal elevation in the gneiss, and the axis is a very straight one, and of considerable length, being prolonged even to the Schuylkill, a distance of several miles beyond the point at which the gneiss itself sinks out of sight.

The middle branch or finger of this area of gneissic rocks is much shorter than either the southern one, just traced, or the most northern, presently to be mentioned. It extends for about two miles westward of the Huntingdon Turnpike, to a point about one mile west of the Pennypack, or to within three-fourths of a mile of Willow Grove. It is an anticlinal belt, embraced between the southern and northern synclinal ranges of the Primal sandstone, into which the eastern end of the limestone basin of Montgomery County forks. This gneiss may be seen on the Pennypack for about half a mile above Shelmire's Mill, and is again intersected, near its western termination, by the road leading south-eastward from Morgan's Mill to Blaker's Store. It terminates in a point about due south of Morgan's Mill.

The most northern branch of the belt of gneiss rocks before us is in reality not continuously connected with the main tract, but is cut off from it by the encroachment of the southern edge of the red sandstone against the northern prong or basin of Primal white sandstone, in the vicinity of the Pennypack. The denudation of the red sandstone, W. of the Pennypack, and N. of Willow Grove, has exposed this patch of the gneiss through a length, bordering the northern side of the Camphill outcrop of Primal rocks, for as much as four miles, and through a breadth, on the Doylestown Turnpike, amounting to about one mile.

Throughout these three western branches of the northern belt of gneiss, the strata are of the same hard massive character as those which constitute the northern tract W. of the Schuylkill, and S. of the Chester County Valley, and there can be no doubt that they are a prolongation of that range. The predominant varieties are hornblendic and felspathic gneiss, with a subordinate proportion of beds of the more micaceous kinds.

Old Plumbago Mine, Buck's County.—Near the Buck Tavern, on the New Hope Turnpike, there is an old mine of plumbago on the farm of Isaac Hogeland. A tradition states that black-lead was procured here more than a hundred years ago. After lying long neglected, the mine was recently reopened, but it is again in a state of dilapidation, and no accurate observations respecting the vein or bed are at present practicable.

NARROW RANGES AND LOCAL OUTCROPS OF GNEISS WEST OF THE BRANDYWINE CREEK.

Southern Belt.—Commencing our description of the more detached tracts of the harder hornblende and felspar varieties of gneiss, constituting the general Southern Belt of the Southern Gneissic Region, where they begin to separate into anticlinal fingers, W. of the Brandywine Creek, the first band we have to notice is one which crosses that stream in the vicinity of Chadd's Ford. This runs towards the western end of Pennsbury Township. The principal variety of the rock at Chadd's Ford is a dark blue and speckled hornblendic gneiss. This anticlinal outcrop seems to end within two miles of the river, but, in the same line of strike, a rock of the same composition is uplifted through the newer strata, in two or three detached broken ridges, all the way to the East Branch of Redclay Creek at Pierce's Paper-Mill. It is probably an extension of the same anticlinal range.

As already mentioned, the Gneiss Rocks basin a little below Chadd's Ford, and in the line of this basin, rests, further westward, a trough of crystalline Auroral limestone, with some Primal sandstone. South of this trough, a much broader tract of the gneiss branches forward toward the W., bounding the Kennet Square Basin of Limestone and its eastern branch, on their south. This belt embraces both hornblendic gneiss and the ordinary grey felspar and mica rocks, the latter being sometimes quite micaceous and full of large garnets.

Approaching the East Branch of Whiteclay Creek, this tract of gneiss begins in turn to subdivide, and at the intersection of that stream it breaks up into three narrow tapering fingers, apparently subsiding anticlinal outcrops, which terminate at, or a little to the westward of, the Middle Branch of Whiteclay. The most northern of these bands crosses this stream a little below Moor's Grist-Mill, the middle Fork reaches it about Wickersham's Mill, and the southern crosses it to the southward of Pennock's Factory, to extend apparently nearly one mile further westward. Between these narrow subsiding belts of the gneiss lie narrow troughs of micaceous and talcose slate, identical, in crystalline and other characters, with similar rocks further N., which I have unhesitatingly referred to the Primal Slate series. The predominant rock in these narrow outcrops of gneiss is the hornblendic variety.

South of the detached fingers of gneiss above described, runs a much more extended and broader tract of the same rock, across the Whiteclay Creek above its forks. The northern edge of this passes the little manufacturing village of Chandlerville, on the East Branch of Whiteclay, and its southern border adjoins the narrow basin of crystalline limestone which includes Nevin's Quarries. This belt stretches towards Kemblesville.

At the main fork of Whiteclay Creek, and for half a mile N.W. of this, we have the broken outcrop of the gneiss, some of the beds of which are of the prevailing hornblende variety. This bounds the trough of limestone on the S.E., and it ranges south-westward into the N.E. corner of Maryland.

Middle Belt of Gneiss on the Brandywine.—Turning next to the middle tract, or that of more micaceous gneiss, we may state briefly, that wherever it displays itself on the Brandywine above Brinton's Ford, or between Brinton's Ford and the main fork of the stream, it is a somewhat decomposable rock, consisting of the ordinary triple mixture of quartz, felspar, and mica, with some strata of thinly-bedded hornblendic gneiss and numerous layers of very micaceous gneiss, full of large garnets. In this group occasionally occur thin bands of a granite-like gneiss, disposed in very regular parallel beds, and having a square fracture, which confers on it an aspect and structure resembling the white Primal sandstone when greatly altered. This gneiss much resembles some members of the formation between Fairmount and Manayunk. Many contortions occur in this zone on the Brandywine, but the prevailing dip is chiefly to the S.E.

Northern Belt of Gneiss near the Brandywine.—A very similar rock to that just described as occurring below the forks of the Brandywine, occurs in the vicinity of Taylor's Ford, and westward from the river towards Marshallton and Trembleville. I conceive it to be not at all improbable, that the northern zone of more massive gneiss, in passing West Chester, subsides towards or beyond the Brandywine, and is there saddled over and swept round by the newer group of more micaceous felspathic gneiss, here interposed between the hornblendic variety and the talcose Primal slates. This, at least, is the most feasible view we can adopt, from the defective data afforded, after a diligent and careful study of the district. The stratification and composition of the strata are necessarily so obscure from extensive metamorphism, and from the occurrence of many imperfectly traceable anticlinal and synclinal undulations, that it is next to impossible to define sharply the respective limits of the formations.

CHAPTER II.

MIDDLE ZONE OF GNEISS,

OR THE GNEISSIC ROCKS BETWEEN THE NORTH VALLEY HILL OF CHESTER COUNTY AND THE SOUTHERN MARGIN OF THE MIDDLE SECONDARY RED SANDSTONE.

Boundaries.—Having described the Gneiss, S. of the limestone basin of Montgomery and Chester, and of the red sandstone in Buck's County, in its several belts and outcrops, and under its different aspects, we come next to the interesting area of the same rocks W. of the Schuylkill, and between the North Valley Hill, as a southern boundary, and the southern margin of the Mesozoic red sandstone and the base of the Welsh Mountain as its northern. From a spot about half a mile west of Valley Forge as its eastern point, the southern edge of this broad belt of gneiss ranges continuously, along the northern base or side of the North Valley Hill, in a direction about S. 70° W., the whole way to the Western Branch of the Octorara in Lancaster County. The northern, or rather the north-eastern boundary, formed by the southern overlapping edge of the red sandstone, is a gently curving line, commencing at the eastern point near Valley Forge, already designated, and terminating at the eastern end of the Welsh Mountain near the county line, between the counties of Chester and Berks. Traced in detail, it passes Wheatley's Lead-Mine near Pickering Creek, crosses that stream at Kenzie's Mill, and then, with a gentle sweep convex south-westward, it passes immediately by the little village of Kimberton. From this point its course is nearly straight to Coventry Village, opposite the junction of the two branches of French Creek. It crosses, in this course, the main French Creek about two miles N.W. of Kimberton, and follows thence to Coventry the north side of the French Creek Valley, except at one bend of the stream opposite Pughtown, where the line for half a mile takes the southern side. From Coventry Village, the boundary between the gneiss and red sandstone, trending first a little N. and then slightly southward, runs nearly due westward for more than seven miles, to the north-eastern point of the main ridge of Welsh Mountain near the village of Springfield. But there is an insulated belt of the gneiss situated a short distance to the N. of this boundary, on the North Branch of French Creek, and this may be more strictly viewed as the northern extension of the formation.

The north-western limit of the wide tract of gneiss before us, is traceable from the sources of Pine Creek, a tributary of the North Branch of French Creek, south-westward along the south-eastern base, first of the eastern spur of Welsh Mountain to Springfield, and from thence along the base of the main Welsh Mountain, over the Lancaster County line N. of the little village of Cambridge, to within two miles of the western end of the ridge.

Viewed broadly, this whole area of the gneissic rocks divides itself westward into two main spurs or broad fingers, the shorter and more northern one terminating at the point just indicated, some two miles E. of the western end of the Welsh Mountain; while the southern, and much longer, extends forward between the North Valley Hill, and the southern base of Mine Ridge, to the North-west Branch of the Octorara, already stated as the westernmost limit of the whole tract. This division of the gneissic area into two western branches is the result of two wide anticlinal undulations, and the reception between them of a broad synclinal belt of the Primal strata, penetrating the gneissic region eastward from the head-waters of the Pecquea in a gradually contracting basin, extending as far as the North Branch of the Brandywine in West Nantmeal Township. This synclinal belt of Primal rocks, a prolongation from the limestone basin of the beautiful and fertile Valley of the Pecquea, is itself a complex trough, penetrated from the eastward by two narrow anticlinal spurs or fingers of the gneissic rocks, causing it to branch into three subordinate troughs. The gneiss may therefore be described as throwing, towards the W., two large and long anticlinal belts, and between these, two others, much shorter and narrower. These latter start off from the main southern division in the neighbourhood of the West Branch of Brandywine, and extend for a few miles a little S. of W., the southern one to a point about one mile E. of the little village of New Italy, and the northern one to about two miles E. of Compassville.

The relations of the geological structure of this district to its topography are such, that the gneissic rocks for the most part constitute the valleys, while the Primal strata form the ridges between them ; the one material being easily eroded, and the other, consisting mainly of hard, firmly cemented, and even semi-vitreous sandstone, opposing a superior resistance to the excavating action of the waters which shaped the surface.

To define now somewhat more exactly the limits of the two principal ranges of the gneiss, or what is the same thing, the southern limit of the Northern belt, and the northern limit of the Southern one, we may state that the first line commences at the West Branch of Brandywine, near Ackland's Grist-Mill, and running almost due westward, follows the south side of the South Branch of Indian Run, leaving the Manor Presbyterian Church to the S. of it about half a mile. Thence, after crossing the West Branch of Brandywine, near McDuff's Grist-Mill, the boundary between the formations coincident, nearly with the north base of the barren ridge of Primal white sandstone, extends along the south edge of the valley of Twolog Run, beyond which it crosses the county line about one mile and a half S. of the village of Cambridge ; and now deflecting northward, and in one mile more, turning again westward across the Pecquea, it runs for three miles further towards the W. end of the Welsh Mountain, to unite with the north-western boundary of the same area of gneiss, already indicated as ending at this point. This wide finger of the gneissic district is bounded, in its western portion on its southern side, by a narrow belt of Primal sandstone and slate, separating it from the limestone of the basin of the Pecquea.

Turning now to the northern limit of the Southern or longer belt of the gneiss rocks, we may approximately define it as crossing the West Branch of the Brandywine, near Waggon Town, and as extending thence towards the W.S.W. along the northern side of the valley of Rock Run, till it crosses Buck Run north of Morris's Grist-Mill, or more than half a mile N. of the E. Sadsbury Friends' Meeting-House. Thence it ranges more nearly westward, to the vicinity of the Mine Hill Gap, passing near the Black Horse. From the Mine Hill Gap, the line, coincident throughout nearly its entire length with the southern base of Mine Ridge, pursues a direction somewhat more southward, till it passes Copper Mine Run in the vicinity of the old copper mine, from which the Mine Ridge derives its name. Beyond this point, to the western extremity of the visible zone of gneiss, the northern boundary observes a course very nearly towards the S.W.

It unites with the southern limit a little W. of the North-west Branch of Octorara Creek, where the belt of gneiss thus bounded ends in an acute point, enclosed by the North Valley Hill and the southern spurs of the Copper Mine Ridge.

There remains to be described only one other subordinate tract of these gneissic rocks, that of the Northern Branch of French Creek. This is insulated superficially from the main area of the gneiss by a long narrow tongue of the Mesozoic red sandstone, and its dykes and ridges of trap-rock extending from Rock Run, where it forks away from the main area of red sandstone, and runs westward to the County line just N. of Springfield. The narrow strip of gneissic ground thus cut off from the main country of gneiss, by the above-mentioned tongue of sandstone, commences in a point near Rock Run, spreads to a width of nearly a mile N. of the Warwick Iron-Mines, and then contracts again, passing the Hopewell Iron-Mines, till it ends in its western point N. of Springfield. This insulated outcrop of ancient gneiss is an exceedingly interesting mineral zone. It includes those well-known, remarkable, mineral localities familiar to the mineralogists of the State, as the Knauer Town Copper-Mine, Steel's Iron Pits, and the Iron-Ore Mines of the Hopewell Furnace, all of which will receive a sufficiently detailed description in a future chapter.

Character of the Gneiss Rocks N. of the Chester County Valley.—A marked difference is presented between the gneissic region N. of the Chester County Valley, and that already described lying S. of it. In the latter district there occurs, as we have seen, a great diversity in the composition of the rocks of the older metamorphic class; there being an abundance, if not a prevalence, of the softer micaceous varieties, and a general deficiency of the more massive granitoid kinds. Here, on the other hand, we encounter chiefly the granite-like varieties of white felspathic gneiss, with hard hornblendic gneiss, such as constitute the typical gneiss rock of the central ridges of the South Mountain, or Highlands between the Delaware and the Schuylkill. By far the most prevalent variety is a felspar-quartz rock, of a greyish white colour, holding only a subordinate amount of mica, and disposed in comparatively massive beds. Certain of the more minutely granulated sorts, of a whitish aspect, resemble so nearly some portions of the Primal white sandstone when excessively crystalline from metamorphic action, that to discriminate between the two formations is by no means easy, but demands the closest care. Nor is this to be wondered at, for the composition of the white Primal sandstone is often just such as would be derived from a white felspar and quartzose gneiss of this description. Micaceous gneiss does occur in the area before us, but nowhere in outcrops of any considerable breadth; and true mica-slate—except merely in thin subordinate layers—has been nowhere met with. Towards the northern side of the region there would seem to be a larger relative amount of massive hard hornblendic gneiss, while centrally, and along the southern border, the white felspathic sort is by much the most abundant.

Of the Undulated Structure of the Gneiss District, N. of the Chester County Valley.—That the wide area of gneiss now under description is undulated in a succession of anticlinal and synclinal waves, is obvious to any practised geological observer who studies its structure with due care. Indeed, the evidence furnished by our map and sections is even more conclusive, as regards this feature, than it is for the gneiss region south of the Limestone Valley, for in that district the closely folded and convulsed condition of the strata renders the detection and tracing of the anticlinals of the gneiss extremely difficult, while here the undulations are, in the main, more open, symmetrical, and susceptible of continuous tracing. Along the northern or north-eastern border of the district, especially S. of the Valley of French Creek, the topographical features, of themselves, plainly suggest the presence of a succession of anticlinals. The present margin of the red sandstone marks pretty evidently the approximate ancient shore-line of that wide estuary, which floated the sediments to form the red sandstone; and this shore-line was determined by the northern sides, and eastern ends, of a succession of hills or anticlinal ridges, which kept off the waters from the country further south. It is only necessary to travel down the Valley of French Creek, from Knauer Town to Kimberton, to recognise the probable truth of this picture. The notion of an undulated or folded structure in the gneiss, finds corroboration in the parallel arrangement of the hills and valleys, and in the sudden changes in the dip of the strata, where-ever we make a transverse section through the region; but it receives its most positive demonstration when we study the topography and distribution of the gneiss on the western side of the county. There, as we have already seen, several long tapering tongues of the Gneiss formation project forward towards the W., including between them actual troughs of the Palæozoic rocks, a feature not attributable to any other mode of elevation of the gneiss than that of an undulation of its general floor, in the manner of long anticlinal waves. Some of these waves, no doubt, are so closely compressed, or folded, and others are so irregularly dislocated, as to render the analysis of them obscure or even impossible, yet the geology of the country clearly establishes their presence.

Faults.—Even in the more central tracts of the district, we are presented with some interesting evidences of these crust-undulations. I allude now to a succession of parallel dislocated synclinal axes, running through West Pikeland and West Vincent townships. Though externally the presence of these *faults* with a synclinal dipping of the strata is not recognisable in any exposures of the strata, the artificial development of the ground, in a series of excavations for valuable deposits of iron ore, has recently enabled me to discover their existence and true structure, and to show that all the principal accumulations of ore are seated upon them. These faults are all connected with the trough-like or synclinal position of the strata supporting the ores. But the most conclusive proof of undulations in the gneiss, and one which accounts for the presence of these deposits of iron ore, is the occurrence at almost every dislocation of an insulated patch of the Mesozoic red sandstone. The iron ore usually rests in a cleft or deep narrow trough, confined between steeply-dipping beds of gneiss, or a wall of granite on the one side, and moderately steep south-east dipping strata of the red sandstone, within or behind which no ore is ever found, on the other. These strata of red sandstone are invariably highly altered and crystalline, for they contain frequently minute crystals of mica, specular iron ore, graphite, and even felspar. Yet, in other layers of mottled and half-baked red shale, in close alternation with these more altered ones, we see proof of their unquestionable identity in composition and origin with the red sandstone formation, from the general southern margin of which, some of them are separated by an interval of four miles. It seems highly probable that, at the completion of the red sandstone deposit, there were several very narrow troughs of it, reposing within some of the deeper valleys lying between the hills of the basin of Pickering Creek; and that at the time of the elevation of the formation, or possibly, contemporaneously with the movements which accompanied the injection of the mineral veins of the Phœnixville and Perkiomen district, these troughs were dislocated longitudinally, and all the superficial red sandstone washed away, except those narrow strips which were caught or nipped within the broken synclinals between the sides of the faults. In this manner we may readily account for the existence of these outlying narrow belts of the red sandstone, and for the presence of the deep and rich deposits of hematitic iron ore which they contain, and which have evidently been derived by percolation from thin strata, by the long-continued trickling of the surface-waters in the lines of fracture. Above the Friends' Meeting-House, a bed of a singular, hard, hornblendic rock crosses the road, appearing also on the road leading from the Yellow Springs to the Red Lion, two miles above the latter place. Pipe-clay occurs in Uwchlan Township, in considerable abundance. Graphite is said to occur in West Nantmeal, disseminated through blue quartz, but none was met with.

IRON ORES OF THE GNEISS.

Brown Iron Ore, or Hematite, of the Basin of Pickering Creek near the Yellow Springs, and the Geological Conditions under which it occurs.—Allusion has already been made to the deposits of brown hematitic iron ore in West Pikeland and West Vincent townships in the Valley of Pickering Creek; and it was stated that these, with very few exceptions, are in close relation with lines of sudden fracture, or parallel longitudinal faults, ranging along the lesser valleys of the district; it was intimated, also, that these dislocations are only so many ruptured synclinal troughs, enclosing narrow belts or outcrops of a material which, by all lithological analogy, can only be referred to the Middle Secondary red sandstone, altered more or less by some igneous metamorphic agency. I shall now offer to the reader some sketches of the three or four principal deposits in the neighbourhood of the Yellow Springs, which have been developed by mining, and which serve best to disclose the law which seems to regulate the distribution of the ore. Commencing with the most north-eastern principal excavation the first which we meet with is one about a mile and a half N.E. of the Yellow Springs on the new road to Kimberton, and on land owned by Mr Lewis.

Lewis's Ore Bank.—This deposit, of which a considerable quantity of good brown hematite is now sent to the Ironworks at Phœnixville, rests in a triangular cleft or narrow trough between steeply-dipping gneiss rock on its S.E., and more gently-pitching altered red sandstone and shale, declining south-eastward at an angle of 45° on its N.W. White felspathic granite occurs near the southern wall of the fissure. The ore itself is confined almost entirely to the loose earthy matter occupying this long open trench, very little of it penetrating the adjoining rocks. It is a somewhat sandy variety of ordinary brown iron ore. The excavations here, all of them open to the day, extend to a depth of between 30 and 50 feet below the level of the soil, and their longitudinal distribution is N.E. and S.W., for this is the direction of the trough which includes the ore. Some of the more altered, or highly crystalline fragments of the red sandstone, contain numerous flat plates or spangles of plumbago, besides crystals of specular oxide of iron. The more argillaceous layers of this outlying fragment of the red sandstone formation, exhibit a less degree of alteration from the normal aspect of the red shale, though they are generally mottled and much discoloured, and even sub-crystalline, and speckled with minute centres of segregation. The topographical relations of this gulf between the strata, containing ore, are just such, it should be observed, as we might look for upon the assumption of a synclinal flexure in the strata, with or without a disruption. In other words, the line of the fault or fissure is centrally along the bed of a narrow but quite extended valley ; and it should be mentioned, that such are the external conditions under which we find nearly all the larger deposits of iron ore in this district. It may not be amiss to state here, that it is in this same line of valley that we find another collection of hematitic ore a little more than one mile to the N.W. of the Yellow Springs ; and it is an interesting fact that the bed of ore, a little S. of Kimberton, lies almost exactly in the same line. I would not, however, here wish to intimate, that either of these two last-mentioned deposits can be recognised as occupying the line of fault in the strata in which we recognise the loose ore. It seems probable, indeed, that the western deposit is not connected with any synclinal trough in the rocks, but is the result of an extensive decomposition of very ferruginous beds of the gneiss. Possibly, however, this part of the valley, like that at the Lewis Mine, may once have been overspread by a narrow thin capping of ferruginous red shale and red sandstone.

Fegeley's Ore Beds, near Yellow Springs.—About half a mile N.E. of the Yellow Springs, two rather extensive excavations have developed a large deposit of the brown iron ore ; one of which is known as Fegeley's Mine. They occur in the bed of a little narrow valley which runs just N. or back of the high hill, at the S. base of which the Yellow Springs are situated, and which is separated from the valley containing the Lewis Ore Bed by a narrow belt of gneissic hills. Both of the ore pits at Fegeley's, lie within one long trough or trench in the strata. This is embraced by steeply-dipping and twisted beds of micaceous gneiss on one side, and by a narrow outcrop of altered red sandstone on the opposite or N.W. side. This sandstone dips south-eastward, at an average inclination of about 40°, to abut apparently against the wall of gneiss rock, making with it a long, deep, narrow trough or trench, 100 feet or less in width at the surface, and in many places perhaps as deep. Irregular injections of half-decomposed felspathic granite penetrate the gneiss of the southern wall of the basin. Ore occurs, confusedly mingled in with the rotted materials of the gneiss and granite, but the main body of the ore is in loose earth resting against the N. sloping wall of red sandstone. The principal excavation at Fegeley's Mine is about 200 feet long, 100 feet wide, and 50 feet deep ; but ore is known to exist in many places in the bottom of the pit. The irregular bed of ore itself is about 40 feet wide.

The outcrop of red sandstone which bounds this line of iron ore on the N.W. forms a low ridge, not more than 200 yards broad, traceable, at intervals at least, by the soil and surface fragments for half a mile or more N.E. and S.W. All topographical indications suggest, that exploration should be made for ore in the line of prolongation of this ore-deposit of Fegeley's.

A short distance to the N.E. of Fegeley's chief ore-pit, there is a yet larger one in the next field, accompanied by corresponding geological features, and where likewise the ore dips to the S.E., reposing against a slanting wall of altered red sandstone. In the bottom of this pit the bed of ore has a thickness or width of about 12 feet.

A careful inspection of the ore and all the attendant phenomena disclosed in these excavations, cannot fail to suggest the notion, that the ferruginous red sandstone is the source of the iron ore, and that it has yielded it up by a process of filtration and percolation of the surface waters, by which it has been carried down into the cleft between the rocks, and left there to concrete.

The average annual yield of Fegeley's Mine is about 2400 tons. It is conveyed to the furnaces at Phœnixville. The mine adjoining Fegeley's, yields yearly about 2000 tons.

ORE-DEPOSITS SOUTH-WEST OF YELLOW SPRINGS.

Latschaw Mine.—A third line or narrow belt of iron ore occurs to the S.W. of the Yellow Springs, commencing probably in the meadows of the Valley of Pickering Creek. S.E. of this attractive place of public resort, two principal mines are seated along this line: one about three-fourths of a mile S.W. of the Springs, known as the Latschaw Mine; the other, about three-fourths of a mile further S.W., called generally the Steitler Ore Bank, owned by Reeves, Buck, & Co. of Phœnixville. These are seated apparently on one line or fault, which brings in contact in a narrow trough, a long narrow outcrop of Middle Secondary red sandstone and steeply-dipping beds of Gneiss. Nearly the same geological conditions prevail at both of these mines, namely, crushed beds of red shale or sandstone dipping to the S.E., and abutting against nearly perpendicular strata of gneiss, with generally an intervening vertical wall of white felspathic granite in a more or less decomposed state.

In the Latschaw Mine, the stratum of red sandstone seems to have been caught in a deep fracture in the gneiss, and greatly squeezed and crushed. The iron ore reposes on the slanting face of this compressed mass of sandstone and of shale, and is even dispersed or mingled through its fragmentary materials along the line of the fault. So crystalline is the red shale and sandstone, and so full of scales of segregated mica and plumbago, that the observer is sometimes at a loss to decide, from hand specimens, whether the rock is really an altered sandstone or a variety of gneiss.

The Steitler Ore Bank.—This valuable deposit of iron ore, evidently lying in the same great fissure in the gneiss which contains the Latschaw deposit, fills a deep triangular trough between beds of crushed red sandstone on the N. side dipping S., and a perpendicular dyke of white felspathic granite, which bounds the gneiss and forms the southern wall of the fissure. Except in the existence here of a more regular and massive dyke of granite, the geological conditions under which the ore occurs are almost identical with those which prevail at the Fegeley and Lewis Mines in the Basins N.E. of the Yellow Springs.

The annexed Sketch represents the relations of the ore, and of the different strata to each other.

The Steitler Ore Bank has been wrought for the past eight years without interruption, yielding annually from 3000 to 5000 tons. It was first worked some fifty years ago by a Mr Vanleer. The ore from this mine is rich, and generally of excellent quality. A little black oxide of manganese, and also a little sulphuret of iron, are occasionally found with the ore. Very beautiful masses of fibrous hæmatite, some of them delicately stalactitic, are frequently met with in this mine, which contains a more than usual abundance of those hollow geodes, which are sometimes called Bomb-shell Ore. It is not uncommon in this and other kindred deposits to meet with beautifully white plumose mica, enclosed within these and other cavities of the ore. The source of such mica, so insulated, is a point of much interest in the theory of the origin of crystalline veins and minerals, and every occurrence of this sort may furnish food for chemico-geological speculation.

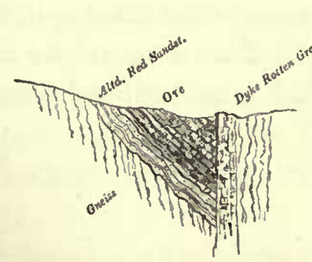


Fig. 1.—Steitler Ore Bank.

Jones' Mine, near Yellow Springs.—This small excavation for iron ore is near the Latschaw

Mine, but not upon the same line with it, being seated upon another rupture in the strata, about one-eighth of a mile S. of that. At this pit there seems to be a line of fault in the strata, filled with fragments of gneiss, of intrusive white granite, and of highly-altered crystalline red sandstone. The iron ore, in a crude and sandy state, is interspersed through this confused mass, which it serves more or less to cement. On the South side of the trench containing the ore, we meet, as usual, with steep strata of gneiss, and on the North side with South-east-dipping beds of a rock which, from its highly crystalline condition, and its abounding in mica and in specular iron-ore, greatly puzzles the observer to determine whether it also is gneiss, or a highly-metamorphosed form of the argillaceous red sandstone. This mine is not at present deep enough to exhibit the geological phenomena in that distinctness under which we witness them at the Steitler and the Fegeley Mines, and some doubt must remain whether we have here another outlying narrow belt of the red sandstone or not. Here is a little sketch, which is deemed to represent correctly what is actually visible at this opening in the strata.

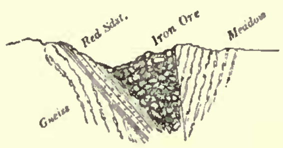


Fig. 2.—Jones' Mine.

Iron Ore in Uwchlan Township.—Iron ore occurs on the West Chester and Pottsgrove State Road, one-fourth of a mile N. of the Little Eagle Tavern in Uwchlan Township. It occurs in gneiss, and evidently at a fault in the strata, and some of the fragmentary rock adjoining. The ore resembles much the altered red sandstone of other ore localities. This ore has not been much explored, and the two or three pits here dug are very superficial. On nearly the same line or strike, similar iron-ore may be recognised near the Morgantown Road, on a farm of Morgan Hoffman, and a small ore pit has exposed good ore in a field, owned by William Parker, nearly in the same line, which coincides almost precisely with the strike of a narrow belt of sparry limestone, which ranges through Morgan Hoffman's farm to George Downing's. Whether this limestone is a true igneous dyke or vein of carbonate of lime, or a closely-compressed synclinal trough of sedimentary limestone metamorphosed by heat, I will not undertake to say. It extends about a mile and a half in a straight line. It is an interesting fact, having some bearing perhaps upon the question of the origin of the iron ores I have been describing, that several of these deposits adjoin, if they are not closely connected with, outcrops or outbursts of limestone. This is the case at the Lewis Ore Bank, where, it is said, a narrow strip of limestone has been uncovered in the excavations for ore. It is likewise true of the locality of Kimberton, where a small exposure of highly-crystalline sparry limestone, with spangles of plumbago, occurs within 100 or 200 feet of the limestone, and we have seen that it obtains also in regard to the ore at William Parker's, which is evidently adjacent to the limestone belt of Morgan Hoffman's farm.

CHAPTER III.

NORTHERN ZONE OF GNEISS,

OR GNEISSIC ROCKS NORTH OF THE MESOZOIC RED SANDSTONE.

GNEISSIC ROCKS OF THE SOUTH MOUNTAINS.

Boundaries.—The South Mountains between the Delaware and Schuylkill Rivers, though of comparatively humble elevation, constitute part of a great mountain system, which extends through New Jersey and New York under the name of Highlands, and through Maryland and Virginia under that of the Blue Ridge.

Entering Pennsylvania at the Delaware River, they occur as a broad tract of nearly parallel but irregularly-connected ridges, ranging in the direction of their length from the N.E. towards the S.W., and having an average breadth of from seven to nine miles, until we approach the Schuylkill. These ridges rarely possess a height of more than 400 or 500 feet above their adjoining or included valleys ; though their bold undulating outlines, and the rugged steepness of their slopes, clothed usually with forest, give to their scenery a prevailing mountain character. Enclosed among these hills, as in so many basins, lie several soft and fertile little valleys, the soil of which reposes on the beds of our Appalachian Auroral limestone. The materials, not only of the well-defined ridges, but of the elevated portions of the tract generally, are either rocks belonging to massive and thick-bedded varieties of gneiss, or they consist of the Primal white sandstone, the lowest in geological position of our older or Palæozoic secondary strata. To the nature of these materials, and to the violence of the uplifting action to which they have been subjected, we must ascribe the rugged and sterile character of these hills. Owing partly to the greater intensity in the quarter next the Delaware of the subterranean disrupting forces, partly to the less thickness in this direction of the white sandstone overlying the gneissic strata, these latter are here much more extensively developed than they are further Westward towards the Schuylkill.

Before entering upon a more detailed account of the areas occupied by the several formations constituting the range of hills before us, let us trace the general boundaries of the whole belt, and show how it is related in geographical and geological position to the other tracts which confine it on the N.W. and S.E. We shall then be prepared to delineate hereafter with precision the situation of the irregular insulated patches of limestone, sandstone, and other materials embraced among these hills.

Geographical Range of the Rocks of the South Mountains.—Tracing, in the first place, the South-eastern limit of the tract, we find it to coincide pretty accurately, along its whole extent from the Delaware to the Schuylkill, with the North-western margin of the Mesozoic red shale and sandstone rocks, which spread to the S. so extensively through Bucks and Montgomery counties, and which here overlap and conceal the group of rocks we are about to describe.

At the Delaware River, the boundary in question passes close to the little village of Monroe, being more exactly marked by a small stream which flows at the base of the hills. Taking a course somewhat W. of S., the line runs about three-quarters of a mile N. of Bursonton ; then crossing Durham Creek, ranges westward to the vicinity of Opp's Tavern, beyond which it bears to the N.W., approaching Leitz's Tavern about two miles S. of Hellertown. From this point the line of division between the two classes of rocks ranges in a direction a little S. of W., until it meets the South Branch of Saucon, about half a mile N.W. of Cooperstown. Here turning rather abruptly, and assuming a nearly South-western course to the head of Hasacock Creek, which it pursues for some distance, it sweeps more to the W. and passes out of Lehigh into Berks, crossing the line not far from the Northern corner of Montgomery.

Entering Berks County, the line crosses the Sumanytown Road a short distance to the N.W. of Ritz's Inn ; then taking a course about 50° S. of W., and nearly parallel with the Montgomery County line, it ranges N. of the northernmost of the two Meeting-Houses in Hereford Township, keeping a little S.E. of Mount Pleasant Iron-Mine, and crossing Swamp Creek about a mile above the county line. It next ranges through Boyerstown to Rhoads' Mill on Ironstone Creek, keeping S. of the road to Kline's Tavern, and curving at the same time Westward and then North-westward, it passes the Manatawny Creek a little below the line of Amity Township. From this point the margin of the tract ranges N. of W. to the intersection of the Limekill Creek and the Township Road of Oley and Exeter. Here it turns again South-westward to follow a somewhat undulating line to the Schuylkill, crossing in its route Monokesy Creek a quarter of a mile S. of Snyder's Mill, then passing near a little church, crossing Rauch Creek, and finally curving round the base of the Neversink Hill to the river.

Along the whole of the line just traced, the Gneissic rocks and the Auroral limestone, where this occurs, are overlaid unconformably by the edge of the Middle Secondary red sandstone. In several neighbourhoods, however, the precise line of junction of the two sets of rocks is difficult to trace, owing to the quantity of soil, gravel, and fragmentary matter lodged near the base of the hills ; this is the case, for example, between the South Branch of the Saucon and the Hasacock. In other places, which will be alluded to hereafter in detail, the overlying rock is not the ordinary red shale and sandstone of the middle secondary series, but a coarse, variegated, and more or less calcareous Conglomerate, identical in geological situation and in aspect with the rock commonly called Potomac Marble.

The North-western boundary of the belt of hills before us corresponds very nearly with the South-eastern edge of the great limestone formation of the Kittatinny Valley. Taken as a continuous line, it begins at the Delaware River, about two miles below the town of Easton. From this point it forms a somewhat undulating border, stretching to the W.S.W. to within two miles of Maiden Creek, a tributary of the Schuylkill, where it suddenly curves to take a direction nearly due S. to Reading. In the earlier part of its range, this line coincides almost exactly with the Northern base of the Lehigh Hills, maintaining thus, from the Delaware to Allentown, a course parallel to the Southern bank of the Lehigh, from which it nowhere far recedes.

South-westward from the vicinity of Allentown, the edge of the limestone bounding the tract may be traced by Emaus, Millerstown, Metztown, and Walnut-town, to the curve near Maiden Creek already alluded to, where, sweeping S., it passes Solomon's Temple, and takes thence the road leading to Reading.

Though the line just traced marks the general North-western boundary of the South Mountains, there occur several small detached hills, lying beyond it to the N.W. The longest and most elevated of these is Chestnut Hill, near Easton. This, which is properly a spur of the general chain in New Jersey, consists chiefly of the gneissic rocks. Another small ridge, consisting also of gneissic rocks, lies in a bend of Monokesy Creek, about three miles N. of Bethlehem. A third still smaller elevation occupies the bend of the Lehigh immediately E. of Allentown, keeping for some distance the Northern side of the river.

Millbaugh Hill.—Westward a few miles from Reading there is an insulated tract of gneiss, forming, with the sandstone of Millbaugh Hill, an elevated district, the last of the chain of the Highlands. Between the Schuylkill and Cumberland County, this is the only representative of the South Mountains of our State. The tract is about nine miles long and two wide, and extends from the Cacoosing into Millbaugh Hill. Its structure is displayed in the General Section No. V.

I shall now exhibit in detail the geological composition and structure of this chain of hills, following the general plan of description already laid down, and tracing the belt from the N.E. towards the S.W.

Composition and Structure.—The rocks which compose this belt of hills between the Delaware and Schuylkill Rivers, appertain to three formations: one group belonging to the Gneissic system, another to the Palæozoic Primal sandstone, and a third to the Palæozoic Auroral limestone. The gneiss and the sandstone enter chiefly into the ridges and hills, while the limestone, the uppermost of the three, partially occupies the synclinal valleys. As the sandstone and limestone formations are members of the great Appalachian Palæozoic system of strata, the delineations of their boundaries and features will be reserved for a future chapter, and my present descriptions will relate only to the rocks of the Gneissic or older metamorphic class.

The *gneiss* of this Northern Belt differs considerably, in its features and constitution, from that of the southernmost tract already described. It is for the most part a massive rock in thick beds, bearing much analogy in appearance to common felspathic granite, except that it is distinctly stratified. Its prevailing character is that of a mixture of felspar and quartz, with but little mica. Sometimes it is a triple mixture of felspar, quartz, and hornblende, and not unfrequently the magnetic oxide of iron is disseminated among these constituents. In certain belts of the Highlands in New Jersey, this last-mentioned mineral is so common an ingredient that it might almost be termed one of the characteristics of the rock. In this felspathic or granitoid gneiss there is present very little mica, talc, or chlorite, or any of the laminated minerals of this order; nor does the chain contain any extensive beds of micaceous, talcose, or chloritic slates, such as occur in the Southern Belt. In the arrangement of the materials of the gneiss there is an obvious tendency to a certain parallelism of the crystals, especially the felspar and hornblende, which are frequently of a flattish form, and occupy thin alternating layers in the rock.

This marked difference in the composition of the predominant rock of the two gneissic ranges must be ascribed to an original difference in the chemical nature of the strata, from which each of these sets of crystalline rocks was formed by metamorphic agencies. Besides the essential want of correspondence between the two regions in the gneiss itself, I have stated that this Northern range contains little or no talcose slate. This is to be explained by the circumstance that in the

Eastern part of the South Mountains, and throughout the chain of the Highlands in New Jersey, there is a general absence, in the lower portion of the Appalachian series, of those slates which, further towards the S.W., adjoin the Primal white sandstone, and which, through igneous action, have been metamorphosed into the talcose and chloritic rocks of those districts.

In its *geological structure*, the chain of the South Mountains or Highlands, between the Delaware and the Schuylkill, presents us with a beautiful example of a belt or group of parallel and somewhat closely-compressed anticlinal and synclinal flexures. A glance at the three general Sections, Nos. II., III., and IV., and at the local sections of this chain, will suffice to show the nature of these bold undulations. It will be seen that from one end of the range to the other, the gneiss, and the older Appalachian strata in contact with it, are bent into a series of *folded or inverted flexures*, having, that is to say, the strata in the N. leg of each anticlinal turned over, and dipping steeply to the S., or rather to the S.E., in accordance with the law so universal throughout our whole Appalachian Chain. Near the Delaware, as shown in both the general and the local sections, there are three distinct ridges of the gneiss, separated by two synclinal troughs of the Auroral limestone. Here the entire breadth of the chain is about 7½ miles. At the Eastern corner of Berks County, where Section III. crosses these hills, their breadth is about six miles. Here they consist almost exclusively of the gneissic rocks. But near the Schuylkill, as exhibited by our sections, the whole belt is much contracted, consisting chiefly of the spurs of the Neversink Mountain, and the ridges are composed almost exclusively of the Primal white sandstone, in an altered and much indurated state. We do not advance far eastward from the river, however, before the Gneiss crops out on the Southern slope of the spur of Penn's S. Mountain, South of the town of Reading.

MORE DETAILED DESCRIPTION OF THE GNEISS AND ITS MINERALS IN THE SOUTH MOUNTAINS.

At the North-eastern extremity of the chain is the insulated ridge called Chestnut Hill. This, which is but the South-western prolongation of Marble Mountain, a spur of the chain lying on the Eastern or New Jersey side of the Delaware, commences at the river, and passing immediately to the N. of the town of Easton, crosses the Bushkill above Hester's Dam, and then subsiding into a long and narrow point, sinks under the limestone near Seip's, about four miles from its origin. Its rocks, which are well exposed at the passage of the river round its Eastern end, consist chiefly of gneiss, its Southern flank alone containing other materials, the more interesting of these being a belt of talc-schist, serpentine, and various associated minerals, among which are zircon, actynolite, augite, silvery mica, soft woolly asbestos, and fine pseudomorphic crystals of serpentine. The gneiss belongs to the massive granitoid variety, so common throughout the whole chain. Its strata dip at a steep angle towards the S.S.E., but exhibit in many places much contortion, implying the violence of the forces which have uptilted them. The same dip is visible in the beds of the talc-slate. The blue limestone of the valley encircles the base of this hill on every side, except just at the passage of the river.

Chestnut Hill presents the mineralogist, at several localities, with beautiful specimens of various mineral species, especially of the magnesian class. The Northern part of the ridge exposes, on the river at "the Weygatt," high, overhanging cliffs of a rock of quartz and felspar, containing veins of epidote. To the S. of this, ranging along the Southern slope of the hill, is seen a band of serpentine and other magnesian rocks, imbedding a great variety of interesting minerals. Next the Delaware, the serpentine is mostly of the yellow sort, containing in places rhombic carbonate of lime, with indurated asbestos, and also grey carbonate of lime in serpentine. Far up the Southern slope of the hill occurs a mass of semi-crystalline greenish-grey augite, including flesh-coloured carbonate of lime. Near the serpentine are several varieties of tremolite, some of it in bladed crystals, some greenish. A little to the westward, near Wolf's Old Quarry, the serpentine abounds with nephrite, some of which is of a beautiful bluish tint, some of a delicate pink hue, and containing small shining crystals of tremolite. A little S. of the nephrite, indeed apparently intermixed with it, are several varieties of talc, as slaty, greenish, whitish, and a scaly green kind. Some of the talc is compact, and is mingled with serpentine, and pervaded with white fibrous carbonate of lime.

To the S. of this locality, there extends another band of coarse quartz and felspar rock, in which some of the felspar is reddish. This portion of it contains crystals of tourmaline and sphene. A belt of this rock occurs at the edge of the river, where it is overflowed at high water; it contains a quantity of soft asbestos, filling the joints. About one mile to the W. of this point, being on the same Southern slope of the hill, and a little W. of the Easton and Wind-Gap road, a beautiful silvery mica was formerly found in abundance, but is now nearly exhausted. Near this occurs a scaly talc, in which good crystals of zircon have been met with. Close to this spot, and near the spring that supplies the town with water, is found a white tabular, crystalline tremolite, some of which is minutely dotted with specks of plumbago; a variety of greenish, tabular tremolite is also here. To the westward of this, in a little cleared meadow, were found specimens of a serpentine rock, containing flesh-coloured and light carbonate of lime, and also irregular masses of tourmaline in a crystalline serpentine. Here, near an old distillery, augite occurs in light-green and earthy-looking crystals, with well-developed terminating faces. Still further westward, toward the Gap of the Bushkill, and a little S. of a syenite rock, which ranges through the ridge, we find a large band of tremolite rock, in the fragments of which are seen crystals of grey tourmaline. West of the Bushkill, on the Eastern sloping face of the hill, we meet with a beautiful dark-green variety of serpentine, some of which has delicate streaks of white, probably carbonate of lime and asbestos. This band of rock is in solid beds, some of them several feet thick, and as it promises to prove susceptible of a fine polish, it may perhaps become valuable as an ornamental stone. It is obviously a *stratified* rock, overlying regularly the syenitic belt of the ridge, which here consists chiefly of sahlite, and dips S.S.E., towards the overlapping limestone of the valley. Between the solid beds of dark serpentine, lie thinner beds of a more slaty sort, with distinct bands of micaceous rock, dividing the serpentine and marking the plane or angle of stratification.

Though upon crossing these crystalline rocks to the Northern side of the ridge, we find them, near the Bushkill, in such close proximity to the limestone as to imply the absence of the generally interposed stratum, the Primal white sandstone, yet to the westward of this a slate is seen, having the appearance of the slaty member of the Primal series, near which occur asbestoid and talcose slates, probably portions of the same low Palæozoic rock. Higher up the hill the blue limestone occurs in place, and adjoining it we find the gneiss. At the first of the above localities, the limestone in contact with the crystalline rocks forms only a narrow tongue or point, running in from the westward, between the main ridge of Chestnut Hill, and a smaller spur which runs out to the Bushkill, a little above the new stone mill. This smaller ridge consists chiefly of serpentine and talcose rocks, bounded at a short distance on the N. by the blue limestone. Some of the talc contains cubic crystals of sulphuret of iron, and some of it is interspersed with fine green serpentine, in which crystals of zircon are said to have been found.

The true direction of the gneissic belt of Chestnut Hill is a little S. of W. Its more elevated portion terminates a little W. of the Bushkill, beyond which the rocks are much concealed by diluvium, cropping out, however, at Seip's Tavern. The high land represented on the Northampton County map as the Western prolongation of the ridge, is not strictly a part of it, but a line of limestone knobs, occurring south of the true range.

Before proceeding to the main belt of the Lehigh Hills, a small insulated ridge, met with about three and a half miles N. of Bethlehem, claims attention. It commences a little W. of the road leading from Bethlehem to Nazareth, and follows the South side of the Monokesy Creek, in the form of a narrow elliptical hill, crossing the stream, and terminating near the road which leads from Bethlehem to Mauch Chunk, a short distance W. of which road its gneissic rocks sink away under the limestone of the valley. This ridge, formed of the same rocks as Chestnut Hill, in the prolongation of which, moreover, it seems to lie, owes its elevation very probably to one and the same uplifting force.

A third detached ridge, consisting chiefly of gneissic rocks, lies between Allentown and Bethlehem, immediately N. of the Lehigh, and parallel with it. The principal rock in this hill is a compound of quartz and felspar, in which, however, are occasional seams of hornblende and epidote. Its northern side is strewed with fragments of yellowish white Primal sandstone, the strata of which appear in place, dipping gently northward, at the Eastern end of the hill, about a mile and a half West of Bethlehem.

Ridges South of the Lehigh.—The chain of the South Mountains, consisting of nearly parallel, though often irregularly-united ridges, will be best described by tracing each belt separately. The first group of ridges extends from the Delaware to Saucon Creek, where a long narrow valley, running in a transverse direction entirely across the tract, separates this from the other belts further to the S.W. Restricting our attention, in the first place, to the group of hills E. of the Saucon, they naturally divide themselves into three ranges: the northernmost, known as the Lehigh Hills, commencing at the Delaware below Easton, and terminating near Hellertown; the middle one, beginning also at the river above Rieglesville, and terminating N. of Cooperstown; and the southernmost, lying S. of Durham Creek, and running from the river to Springtown.

The first of these, the Lehigh Hills, bounding for some miles the valley of the Lehigh River on the S., and commencing in a loop of the Delaware about two miles below Easton, ranges towards the S.S.W., and gradually approaches the Lehigh, until the gneiss rocks show themselves on the river-bank, about a mile and a half below the mouth of Saucon Creek. Near the East Branch of this stream the chain separates, enclosing small tracts of limestone between its spurs. The gneissic rocks occupy the margin of the river for only a short distance, the limestone, their usual boundary, resuming soon its place on the Southern side. This belt of the gneiss terminates near the bridge over Saucon Creek, between Shinersville and Freemansburg, the limestone folding round the base of the hill, and extending up the East Branch of Saucon. Between this East Branch and the Main Creek lie two other ridges or spurs, nearly in a line with the chain just mentioned, the Southern one terminating E. of Hellertown, and the other further northward. Between them is a narrow limestone valley, which contracts in breadth towards the E., and heads near the Little or East Saucon. Though a separate chain of elevated rocks, the Northern belt here described is not entirely detached from the middle range already referred to, a tract of crystalline rocks lying round the head of the Little Saucon, serving to connect them geologically.

In the general prolongation of the chain, but disconnected from the previous set of ridges by the transverse valley of the Saucon and its South Branch, we have the Metamorphic or gneissic rocks extending towards the S.W., through the lower townships of Lehigh and Berks, in a series of nearly parallel spurs, almost to the Schuylkill. In describing the general South-eastern and North-western boundaries of the whole chain through Lehigh, we have already given very nearly the true limits of these rocks in that county. This part of the belt is separated longitudinally for several miles, into two parallel sets of ridges, by the upper part of the valley of the Saucon. One of these tracts, lying W. and N. of that creek, commences at the Lehigh, near Bethlehem, and ranging S. of Allentown, and past Emaus and Millerstown, passes into Berks, losing there its character as a distinct zone of hills; the other originating W. of the South Branch of Saucon, ranges South-westward to the head-waters of Perkiomen Creek, where it merges westward into the general belt. On both sides of the county line, dividing Lehigh and Berks, the Gneiss Hills compose an unbroken tract having a breadth of about six miles. Passing still further to the westward, the general chain expands in width, but becomes subdivided by valleys entering it from the S. and W.; the broad gneissic tract being broken into about five spurs or ranges, and the intervals between them occupied by belts of limestone and sandstone, the latter often forming hills as elevated as those of the gneiss. The northernmost subdivision of the gneiss, starting from the general belt in Rockland Township, terminates about three miles E. of the mouth of Maiden Creek, near the head of Dry Run. It is bounded on the N.W. by a narrow undulating belt of the Primal sandstone, which, from the neighbourhood of Metztown to Solomon's Temple, separates the gneiss from the limestone of the Kittatinny Valley. This tract of the gneiss is bordered on the S. by a long narrow tongue of the same sandstone, starting off from the main mass of that formation E. of Solomon's Temple, and running eastward past Pricetown as far as Shiffert's Inn. W. of Penn's Mountain, which consists of the sandstone, and S. of the Pricetown range of the same rock, lies another nearly-detached tract of the gneiss, bounded on the E. and S.E. in Oley and Exeter townships by the Primal slates and the Auroral Limestone. The margin of this large patch of strata is made so excessively irregular, by the protrusion into it of the spurs of sandstone, as to render it impossible to describe it intelligibly in words. A third spur of the general chain occupies the Southern half of Rockland Township, between the two head-streams of Manatawny Creek. A fourth smaller spur projects to the S.W., forming the Northern corner of Pike Township. It is bounded by Pine Creek on the N.W., and by another parallel stream, also a tributary of the Manatawny, on the S.E. A fifth and much larger tract of the crystalline rocks fills the South-eastern part of Pike, the North-western two-thirds of Colebrookdale, and the Northern half of Earl townships. It is limited on the N.W. and W. by a long, narrow, curving belt of the sandstone, which follows the Eastern side of the tributary just mentioned, and then the Main Creek. Its Eastern border passes through Colebrookdale Township, from Perkiomen to Ironstone Creeks, making here a gently-undulating line, nearly parallel with the Montgomery County line. This South-eastern edge of the gneiss is

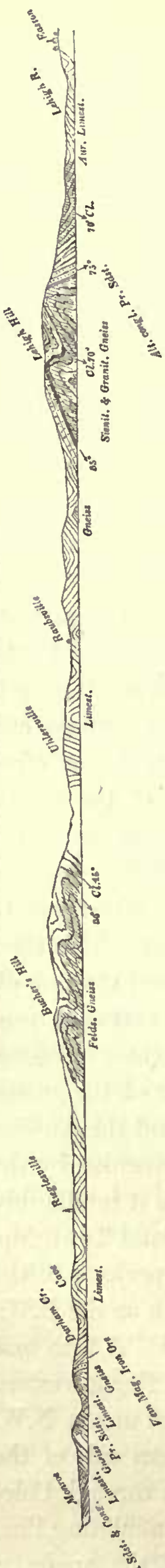


FIG. 3.—Section on the Delaware from Easton to Monroe, looking S.W.

formed by the margin of the overlapping red sandstone of the Middle Secondary period, except at a few points, where small patches of the limestone and white sandstone intervene. Between the head of Ironstone Creek and the main Manatawny, near Spang's Furnace, there extends a small ridge of the Primal white sandstone, which separates the Gneiss tract along its southern limit into two divisions. A line drawn from a point on Ironstone Creek, about a mile S.W. of Boyerstown, westward to the end of this sandstone ridge, will mark with tolerable accuracy the general limit of the Gneiss on the S.

STRATIFICATION OF THE SOUTH MOUNTAINS, AS SEEN IN TRANSVERSE LOCAL SECTIONS.

Section (A.)—*Along the Delaware River W. side* (*looking S.W.*)—The best natural exhibition of the structure of the Delaware and Schuylkill division of the South Mountains, indeed the only good one, is that along the first-named river from Easton to Monroe. Reserving for a future chapter the longitudinal tracing of the synclinal belts of the Palæozoic strata, their positions and features in the sections will be noted here, as essential to a clear understanding of the constitution of the chain.

Commencing at the mouth of the Lehigh, we first encounter the Auroral limestone of a dark blue colour and ferruginous aspect. Near the Lehigh Bridge its strike is irregular, for it dips to S. 20° to 45° W., at an average angle of 25°. The rock shows some metamorphism, is massive and free from joints, but displays a transverse cleavage dipping 60° to S. 40° E. The S. dip continues for two-thirds of a mile below the Lehigh, but is steeper when it changes to a gentle N. dip of 20°. Approaching the foot of the Lehigh Hill it becomes more altered and slaty, the partings between the beds being covered by a thin micaceous film; here the cleavage planes are more conspicuous than the planes of bedding. It is worthy of note that in this locality the strike of the cleavage is not coincident with the strike of the Palæozoic rocks to which it belongs, nor yet with the strike of the Gneiss upon which they unconformably repose. The strike of the Gneiss in this district varies from N. 50° E. to N. 45° E.; that of the Palæozoic rocks is usually about N. 65° E. But the strike of the cleavage planes of the latter, though approximately conformable to that of the beds, is generally more E. and W. by several degrees. In the general direction of their dip, the cleavage planes observe the usual law, declining steeply to the S.E.

Quitting the limestone, and crossing a space of 500 feet without exposures, we come upon the Primal rocks of the Northern flank of the Lehigh Hills in a highly-altered condition; the first met with are numerous fragments and masses of the Primal silicious slates, and the Primal white sandstone, but not in place. From beneath these, rise massive beds of a grey quartzose conglomerate, greatly altered by igneous agency. Its pebbles, of pea and nut size, are in fused contact with a syenite or syenitic gneiss of felspar and augite, the whole rock so altered that its sandy paste contains regularly-formed crystalline felspar. It is at once a conglomerate and a porphyry. These beds dip 75° to N. 40.° W.

From below the Primal rocks rises an arch or anticlinal wave of granitoid gneiss with thin injections of syenite. On the S.E. side of this anticlinal ridge of gneiss, the Primal sandstones and slates again appear all highly altered, some layers of the slates being porphyroidal. Here the dip is about 35° to the S.E. Between these two exterior belts of Primal strata flanking the ridge, there occurs a narrow compressed trough of the same rocks, involving a synclinal fold of the lowest beds of the Auroral limestone. The Lehigh Hill appears, therefore, to contain two folded anticlinals.

Unconformity of the Primal Strata to the Gneiss.—The precise angle of dip of the underlying Gneiss is not well exposed, but it seems at the N. base of the hill to be steeper than that of the Primal conglomerate, implying a movement of the older rock before the deposition of the materials of the newer. In other localities, embraced within this line of section, the want of parallelism between the two systems of strata is better displayed.

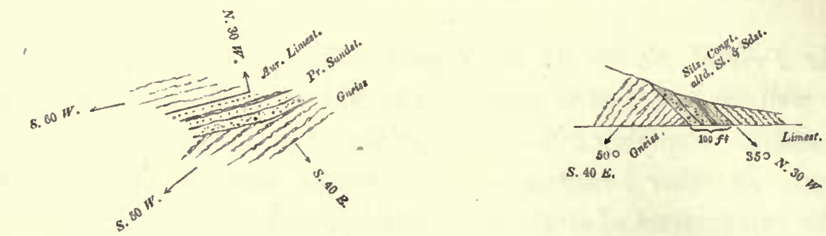
Between the Southern foot of the Lehigh Hill and the Northern base of Bucher's Hill, there intervenes a comparatively wide and smooth valley of limestone. This trough rapidly contracts and descends south-westward, terminating about two miles from the river ; it is not a simple synclinal belt, but contains some two or more anticlinal undulations in the limestone. Between the Northern limit of this basin at Raub's Ferry, and the immediate Southern base of the Lehigh Hill, we detect another small trough of the limestone, separated from the main one by a mere narrow point or spur of the older crystalline rocks. Along our line of section there are several large quarries of the limestone at eligible localities facing the river. One of these displays Ripple Mark on a truly superb scale. This quarry is close to Uhlersville.

The next belt crossed by our section is the tract of Gneiss known as Bucher's Hill. Generally the strata are seen to dip to the S.E. at an average angle not exceeding 45° ; they are undulated in at least two or three folded flexures, the axis planes of which observe the prevailing law, dipping South-eastward. The gneiss here is the prevailing greenish and white felspathic variety.

Between Bucher's Hill, which is the middle ridge, and the Durham Hill, or most Southern of the three anticlinal belts, lies another synclinal trough of the Auroral limestone, skirted in one or two places by exposures of the Primal sandstone. This belt occupies the valley of Durham Creek, as far to the S.W. as Springtown, being on the river, rather more than a mile wide. At Durham Furnace the rocks are well exposed. Between the furnace and Durham Creek they exhibit a regular anticlinal flexure. This is the locality of the well-known Durham Cave, remarkable for the Mammalian Bones which were discovered in it, and which I shall hereafter allude to when enumerating the fossil remains of our Bone-bearing Caverns. The cave is situated on the North side or steeper flank of the anticlinal arch, which will be found, I think, to be the prevailing position of these limestone caverns in the valleys of the Appalachian Chain.

Durham Hill.—The last belt which the section crosses is that extending between Durham Creek and Monroe. The gneiss forming the ridge between the Durham and the Monroe valleys, is at the river only about one mile broad ; it is indeed merely a spur of the Musconetcong Mountain sinking down. Its structure is that of a double anticlinal, embracing a very shallow synclinal band of Primal strata and Auroral limestone between the two flexures. On the N., towards Durham Creek, this gneissic belt is flanked by a narrow outcrop of the Primal strata succeeded by the limestone. Here we detect one of the most interesting instances of unconformity of dip between the Palæozoic and the Gneissic or Hypozoic rocks, anywhere to be met with in the South Mountains, or indeed in the Appalachian Chain. The appended little section and diagram will illustrate the discordant relation of the two systems, both in dip and strike, and serve to bring out distinctly the magnitude of the crust-movement which occurred between the periods of deposition of the two sets of strata.

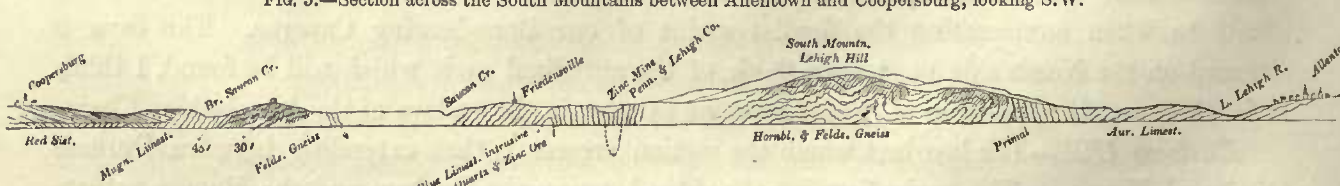
Fig. 4.—Unconformable contact of the Primal Rocks and the Gneiss.



At the North base of the hill, the Gneiss, syenitic in its composition, dips 50° to S., 40° E., being probably the inverted leg of a folded anticlinal. The Primal rocks lean upon the denuded edges of its beds dipping in a nearly opposite direction—namely, 35° to N., 30° W. The whole Primal group is here about 100 feet thick, and consists of a lower member,—a dark silicious conglomerate, and an upper, composed of alternating beds of altered white sandstone and altered silicious slate. Upon these repose the lower beds of the Auroral limestone, conforming in dip and strike with the sandstone. On and near the road we discern an equally remarkable discordance of *strike*, that of the Gneiss being S. 50° W., while that of the Primal and Auroral rocks is S. 60° W., or 20° away from parallelism. (See Ground Plan.)

On the South flank, or rather at the South base of the Durham Hills, reclines a narrow outcrop of the Auroral limestone, consisting of white magnesian limestone, greenish talcose slate, and blue limestone. Abutting abruptly against the latter, we come suddenly on the conglomerate, which terminates the unconformably overlying Mesozoic red sandstone. This rock is here a true puddingstone, being composed of pebbles of all the adjacent older uplifted rocks,—Gneiss, Primal sandstone and slate, and Auroral limestone,—imbedded in a paste of red shale. The conglomerate dips 30° to N., 30° W., while the limestones, somewhat twisted, lean to the S. 25° E., at a varying angle of from 30° to 60°. This interesting spot marks one point along the Northern shore of the broad red sandstone estuary, skirted by a bold range of hills with comparatively deep water at their base, where the crust-disturbances which lifted and drained the district shook down a large body of fragmentary matter, to be rolled and imbedded by the waters along their base.

Fig. 5.—Section across the South Mountains between Allentown and Coopersburg, looking S.W.



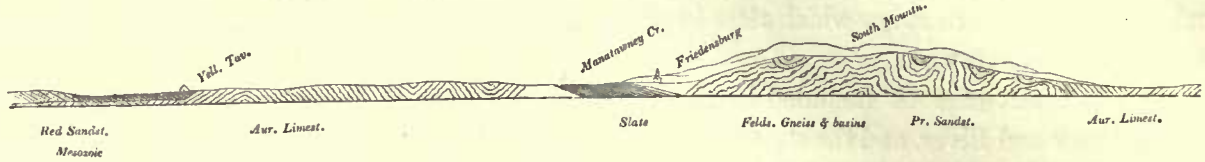
Our next local section designed to exhibit the structure of the chain, extends south-eastward from Allentown on the Lehigh, to Cooperstown near the South Branch of the Saucon, a distance of about seven miles. The chain as here exhibited is of simpler features than where it is cut by the Delaware, for the southern and central ridges having both expired south-westward, before reaching the neighbourhood of our section, the only divisions of the chain presented are, the main Northern anticlinal belt in westward prolongation of the Lehigh Hill of the Delaware, and a lesser Southern ridge which rises in the forks of the Saucon, and extends south-westward towards the Manatawny.

The first belt of rock included in the section is the Auroral limestone of the valley of the Lehigh Creek and River, and the strata dip and undulate almost precisely as they do S. of Easton, in a corresponding position at the base of the hills: that is to say, they display an anticlinal axis, which a little further eastward, or just S. of the acute bend of the Lehigh, lifts to the surface even the Primal sandstone. Whether the sandstone is directly in contact with the Gneiss, or separated from it by a narrow outcrop of the Primal rocks, we are unable, from the absence of exposures, to state.

The general structure of the ridge dividing the valley of the Little Lehigh Creek from that of the Saucon, is apparently the same as that of the Lehigh Hill near Easton, or in other words, it contains a compound anticlinal, with steep or even inverted north-westerly dips, and more moderate south-easterly ones not exceeding 60°. The rock of the Southern slope of this ridge is for the most part a hornblendic gneiss, that near the crest is a binary granitoid gneiss of quartz and felspar. An obscure slaty cleavage pervades certain portions of the Gneiss, the plains dipping generally at a steep angle, about 75° towards the S.E. Between the South-eastern base of the Lehigh Ridge, and the Northern foot of the subsiding gneissic ridge of the Saucon, there spreads a smooth open valley of limestone occupied by the Saucon Creek. Branching southward it receives the South Fork of that stream, flowing through another smaller limestone basin. Our section-line passes over the Eastern point of the ridge of Gneiss, which separates the main Saucon Valley from its southern lateral branch. The Gneiss near the end of the ridge dips at a gentle angle towards the S.E., though further to the S.W. this ridge, like that N.W. of the Saucon, is anticlinal in its structure. The limestone belt of the main Saucon appears to be undulated; a steep anticlinal axis ranging between the village of Friedensville and the Zinc Mine. This interesting mine of Calomine, or the silicious oxide of zinc, occurs in a close synclinal fold of the Auroral limestone, near the South base of the Gneissic Hills. Passing the spur of Gneiss of the Saucon Ridge, we enter a narrow belt of South-east-dipping limestone near the South Branch of the Saucon. This limestone may be seen almost in contact with the gneiss which supports it, its own beds dipping at an angle of 45°, those of the Gneiss dip 30° to the S.E.; thus presenting us with another instance of unconformity between the two systems of strata. In this case, besides the want of parallelism, there is an absence of the whole Primal series, the result either of a dislocation in the strata, or of a suspension of sedimentary action in the Primal period at this place, or possibly it has arisen from the overlapping of the limestone past the original margin of the sandstone, as both were deposited unconformably upon the Gneiss.

Crossing the South Branch of the Saucon, our section immediately enters the wide area of the Mesozoic Red Shale and Sandstone, there terminating in the upper conglomeritic beds of that formation, which abut, with a gentle North-westerly dip, against the more steeply South-east-dipping beds of the Auroral limestone, under conditions of contact very analogous to those presented at Monroe. The red shale formation is well seen half a mile northward from Coopersburg, where its beds show a dip of only about 10°. Here the rock exhibits distinct ripple-marks. No capping stratum of conglomerate is visible, though the debris of that rock occurs near the Hellertown Road ; it has probably been swept away by denuding waters.

FIG. 6.—Section across the South Mountains, nine miles east of Reading, through Friedensburg, looking S.W.



This section, like the two already described, commences in the Auroral limestone of the Kittatinny Valley beyond the North base of the Gneissic ridges of the South Mountains. Passing one or two flexures in the limestone, the section crosses a branch of Maiden Creek, and soon meets the material of the Primal sandstone, showing a wide, gently-ascending plain to the margin of the Gneiss at the foot of the hills. Some portions of the sandstone are pebbly. Entering upon the Gneiss, our section crosses an undulating belt of moderately high hills, some five miles in width, to the Slate Valley of Friedensburg, which it first touches near Monokesy Creek. This wide belt of hills consists in part of Gneiss, in part of Primal White Sandstone ; the latter formation, though seldom seen in place, occurring evidently in narrow synclinal basins included between the anticlinal undulations of the Gneiss, which, for the most part, occupies the higher ridges. (See Fig. 6—Section, 9 miles E. of Reading.)

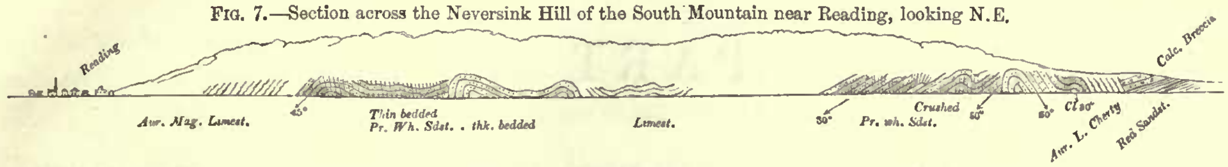
From the foot of the Gneiss Hills, west of the Monokesy, the section traverses a smooth gently-undulating plain, the whole way to the Northern margin of the Mesozoic Red Sandstone. In the space of about four miles, the first two miles, following the Friedensburg road parallel to the section, cross Primal Upper Slate, occupying a broad outcrop before it dips beneath the Auroral limestone basin of the Manatawny and Monokesy. The remainder of the distance is across the Auroral limestone, which exhibits several undulations. The Gneiss of the hills traversed by our section is identical in constitution with that of the Lehigh ridge further north-eastward. The Primal series, besides containing much white sandstone, embraces beds of a coarse conglomerate.

Cleavage abounds, especially in the Palæozoic strata crossed by this section, and dips almost invariably at a steep angle towards the S.E., obedient to the prevailing law of cleavage-dip in the Appalachian Chain. This structure is plainly shown in the limestone S. of Maiden Creek, the planes dipping S.E. ; the Gneiss itself in the first hill shows cleavage, dipping very steeply to the same quarter, the strata themselves dipping 45° southward. On the Manatawny the bluish upper Primal slates display cleavage, dipping eastward 45° or 50°, the beds dipping 10° to the N.E. : south of the stream the cleavage-dip is still S.E., but at as low an angle as 35°. Further on in the limestone, the true dip of which is often obscure, the cleavage-dip maintains its usual direction.

Our section terminates in the red sandstone formation, which contains, as its uppermost deposit, a calcareous conglomerate apparently dipping in the very unusual direction of S.W. at an angle of 45°. At another locality near the section, its dip is to the W. 30° ; and one and a quarter miles from the Yellow Tavern the conglomerate, well exposed on the road, seems to dip a little S. of W. as steeply as 50° or 60°. These irregularities in strike and dip imply some local disturbance, an inference which is rendered probable from the occurrence of many joints intimating partial metamorphism.

This section, designed to exhibit the structure of the Neversink Hill near its termination at the Schuylkill, commences a little below Reading in the Auroral limestone, embraces the excellent

FIG. 7.—Section across the Neversink Hill of the South Mountain near Reading, looking N.E.



succession of exposures of the rocks afforded by the cuttings along the Reading Railroad, and terminates in the Mesozoic conglomerate at the South-eastern base of the hill about three miles below the town. It displays none of the older Metamorphic strata, but only the Primal rocks and the Auroral limestone reposing on them. Even in this depressed termination of the chain we may detect the presence of the two main anticlinals which undulate the strata of the hills for several miles thence to the N.E. Passing from the Auroral limestone of the North-western base of the hill, dipping with considerable irregularity at a steep angle, towards the first main flexure of the Primal White Sandstone which ranges under its central crest, the section crosses a belt of undulated and crushed sandy ferruginous slates, highly indurated and much intersected with cleavage. These are the Primal upper slates resting upon the Primal sandstone. This latter exhibits a double or compound flexure, the steep limb of the arch being towards the N.W., in obedience to the more prevailing rule.

Towards the lower end of the section, exposed in another deep cut of the railroad, another normal arch or flexure of the Primal sandstone displays itself, the steeper or North-western side dipping perpendicularly, and the gentler South-eastern, at an angle of 60°. For some distance N. of this, the Primal White Sandstone, succeeded by the Primal newer slate, highly indurated and crushed, exposes a prevailing dip to the N.W. of about 30°. Between the two main anticlinals of the mountain there is evidently a deep synclinal trough rising rapidly north-eastward into the hill, but at the railroad containing a basin, or rather a cove, of the Auroral limestone, evidently much contorted by pressure and metamorphosed by the action of heat. On the South-eastern flank of the Southern anticlinal, we detect a narrow outcrop of the same limestone, leaning at a steep angle upon the Primal rocks. Throughout this section these Auroral strata and the Primal slates and sandstone supporting them, display a very decided amount of metamorphism, and it is interesting to notice that the cleavage—one of the more conspicuous symptoms of this change—observes the usual law, and dips steeply to the S.E., or parallel to the average direction and angle of the axis planes of the flexures, manifesting at the same time its usual fan-like divergence where it is in immediate proximity to the lesser anticlinal and synclinal curves.

The section illustrates the fine exposure of the Mesozoic Conglomerate, or uppermost stratum of the great Red Shale formation visible at the Railroad. It is here more than usually calcareous, but contains, besides its numerous pebbles of the Auroral limestone, others referable to all the contiguous formations of older date than itself. The conglomerate, dipping about 15° to N. 20° E., abuts directly against the steeply-southward-dipping beds of the Auroral limestone. It is evident that the conditions attending its origin were precisely identical with those which witnessed the production of the same deposit in the region of the Delaware, as already explained; namely, a wild strewing of pebbles, the fragments of the earthquake-shaken hills which composed at the time the northern shore of the Mesozoic waters.

PART II.

PALÆOZOIC, OR ANCIENT FOSSILIFEROUS STRATA OF PENNSYLVANIA.

INTRODUCTORY BOOK.

CHAPTER I.

A SYNOPSIS OF THE APPALACHIAN PALÆOZOIC STRATA OF PENNSYLVANIA IN THE ASCENDING ORDER.

Primal Crystalline Schists (*or Azoic Group*). — This is a very thick and widely-diffused group of semi-crystalline strata, — indurated clay-slates, talcose, micaceous and hornblendic schists, and grey silicious grits,—without visible fossils, but in close physical relation with the overlying fossiliferous Primal rocks, and apparently a portion of the Palæozoic system.

PRIMAL SERIES.

Primal Conglomerate.—A heterogeneous conglomerate composed of quartzose, felspathic, and other pebbles, imbedded in a silicious or talco-silicious cement. This rock does not appear in Pennsylvania, but is largely developed in Virginia and Tennessee, where it has a thickness of 150 feet. This formation and the preceding seem to lie below the lowest ascertained fossiliferous horizon.

Primal Older Slate.—A sandy slate of a brown and greenish-grey colour, containing much felspathic and talcose matter. It has hitherto disclosed no fossils. The thickness of this rock has not been ascertained in Pennsylvania, the beds being too much folded. In Virginia it is 1200 feet thick.

Primal White Sandstone (*Potsdam Sandstone of New York*).—A compact, fine-grained white and yellowish vitreous sandstone, containing specks of kaolin. This stratum is distinguished by a cylindrical stem-like fossil, *the Scolythus linearis,* which crosses the beds in a perpendicular direction. Probable thickness about 300 feet.

Primal Upper Slate.—A greenish-blue and brownish talco-argillaceous slate, sometimes very soft and shaly. Its only fossil a peculiar fucoid. It is probably about 700 feet thick in Pennsylvania.

AURORAL SERIES—(BLUE LIMESTONE OF THE WESTERN STATES).

Auroral Calcareous Sandstone (*Calciferous Sandstone of New York*).—A coarse grey calcareous sandstone, containing drusy cavities, enclosing crystals of quartz and calcareous spar. Within the limits of Pennsylvania this occurs chiefly in Northampton, Centre, and Huntingdon counties. It is about 60 feet thick at Easton.

Auroral Magnesian Limestone. (*The Chazy and Black River Limestones of New York are parts of this formation*).—A light-blue and bluish-grey massive limestone, containing generally from ten to thirty per cent of carbonate of magnesia. In the south-western portion of Pennsylvania it contains thick beds of chert. Its thickness is from 2500 to 5500 feet.

MATINAL SERIES.

Matinal Argillaceous Limestone (*Trenton Limestone of New York*).—A dark-blue and bluish-grey, soft, argillaceous limestone, alternating near its upper limit with blue calcareous shale. This whole formation is very fossiliferous, being characterised by the *Chætetes lycoperdon, Leptæna sericea, Bellerophon bilobata, Isotelus gigas,* and many other fossils. In Northampton, Mifflin, and Centre counties, it is from 300 to 550 feet thick.

Matinal Black Slate (*Utica Slate of New York*).—A blackish and dark-blue fissile slate, usually very carbonaceous, distinguished by *Graptolites, Orbiculæ,* and other characteristic fossils. It appears in Northampton County and in Kishicoquillas Valley. Its thickness is from 300 to 400 feet.

Matinal Shales (*Hudson River Slates of New York*).—Bluish-grey shales and sandy slates, containing, especially in their upper portion, many beds of argillaceous sandstone, and some layers of dark-grey silicious conglomerate. In the western parts of Berks and Lebanon, the formation contains much red and reddish-brown slate, alternating with yellow layers. The middle portion, in certain localities, yields a tolerably good roofing-slate. It has many characteristic fossils, especially a species of *Graptolithus,* of *Heterocrinus,* of *Orbicula,* of *Modiolopsis* and other Acephala, and of several *Trilobites.* It contains some species common to it and the Matinal argillaceous limestone. Thickness in Centre County, 1200 (?) feet.

LEVANT SERIES.

Levant Grey Sandstone (*Oneida Conglomerate of New York*).—A compact greenish-grey massive sandstone, containing, in many places, thick beds of silicious conglomerate. From 250 to 400 feet thick in many ridges in Centre and Huntingdon counties.

Levant Red Sandstone (*Division I., or Lowest Member of the Medina Sandstone of New York*).—A soft argillaceous red and brown sandstone and red shale. It contains few or no fossils. In Centre and Huntingdon it is from 500 to 700 feet thick.

Levant White Sandstone (*apparently Divisions II., III., and IV. of the Medina Sandstone of New York*).—A white or light-grey sandstone, rather fine-grained, very hard and massive, alternating at its upper limit with greenish shales, and containing there thin-bedded and mottled-grey and red sandstone. These upper beds are often covered with a network of the impressions of large articulated marine plants, especially the *Arthrophycus Harlani.* The freshly fractured surfaces of the lower beds are generally dotted with yellow ferruginous specks. In some outcrops the whole mass is 450 feet thick.

SURGENT SERIES.

Surgent Lower Slate (*probable equivalent of Lower Green Shale of Clinton Group of New York*).—Olive-coloured and yellowish slates, containing but little calcareous matter, and including thin sandy beds. Some of its layers acquire, by exposure, a peculiar claret colour. Characterised by the little branching fucoid *Buthotrephis gracilis,* and other fossils. This formation is in some places 200 feet thick.

Surgent Iron Sandstone.—An alternation of red and ponderous ferruginous sandstone, red argillaceous sandstone, and green sandy slate. The red sandstone very usually contains two or three thin beds rich enough in iron to be valuable as an iron ore. In the Kittatinny Mountain, on the Susquehanna, it is 80 feet thick.

Surgent Upper Slate.—A green fissile slate, changed at its outcrop into a buff-coloured, and sometimes a claret and brownish, slate. It contains thin layers of argillaceous sandstone, and abounds in the small branching fucoid *Buthotrephis gracilis.* Its thickness frequently exceeds 250 feet.

Surgent Lower Ore Shale (*part, perhaps, of the Upper Green Shale of Clinton Group, New York*).—A greenish fissile shale, with thin layers of limestone. This formation sometimes contains a band of the red fossiliferous iron ore. It has a thickness near Jack's Mountain, on the Juniata, of 760 feet.

Surgent Ore Sandstone.—A tough grey calcareous sandstone, with thin partings of shale. It is from 10 to 30 feet thick.

Surgent Upper Ore Shale (*probably on horizon of Upper Green Shale of Clinton Group of New York*).—This formation consists, in Pennsylvania, of an alternation of bluish and greenish shales and fissile slates, with thin beds of argillaceous and sometimes pure limestone, and occasionally thin beds of calcareous sandstone. Its lower portion is characterised by the well-known red fossiliferous iron ore, in one or more thin layers. It abounds in *Beyrichia* and other fossils. On the Juniata it is 300 feet thick; in some places even more.

Surgent Red Marl (*Clinton Group of New York*).—A red, slightly argillaceous shale of very uniform composition. It contains scarcely any fossils. Its thickness on the Juniata is in some places 350 feet.

SCALENT SERIES.

Scalent Variegated Marls.—An alternation of blue, green, and red marly shales and fossiliferous limestones; the red shale more abundant towards the bottom. It contains *Cytherina alta, Avicula alta,* and other shells. Thickness on the Juniata, about 400 feet.

Scalent Grey Marls (*probably this and the Scalent variegated Marls represent the Onondago Salt Group of New York*).—Ashy, greenish blue, and grey calcareous marls and shales, with occasional beds of impure argillaceous limestone. It graduates upward into the Cement Rock. Thickness on the Juniata, 800 feet.

Scalent Limestone (*Water Lime Group of New York*). A blue flaggy limestone, sometimes containing bands of chert. Certain portions have a thinly-bedded, wavy stratification. It is frequently highly magnesian, and is extensively employed, especially in New York, for making hydraulic cement. This rock contains the *Cytherina alta, Tentaculites ornatus,* and a few other distinctive fossils. Thickness on the Juniata, 250 feet.

PRE-MERIDIAN SERIES.

Pre-meridian Limestone (*Lower Helderberg Limestone of New York*).—A diversified calcareous formation, usually of some shade of greyish blue. It is argillaceous and flaggy in its lower beds, and shaly towards the middle. It frequently contains layers and nodules of chert, especially near its upper limits. It has many characteristic fossils, the *Pentameris galeatus,* and other shells, with corals. The average thickness of this rock is between 50 and 100 feet.

MERIDIAN SERIES.

Meridian Slate.—A dark ash-coloured and blackish slate, passing upwards into a dark ashy grey sandy calcareous rock. It has its greatest thickness on the Upper Juniata, near Frankstown, where it is 170 feet.

Meridian Sandstone (*Oriskany Sandstone of New York*).—A coarse, yellowish, calcareous sandstone, graduating near its upper limit into a fine-grained quartzose conglomerate, and becoming in its lower beds a coarse arenaceous limestone, characterised by the *Atrypa elongata, Spirifer arenosus,* and other remarkable large Brachiopodous shells. Its greatest thickness on the Juniata is about 150 feet.

POST-MERIDIAN SERIES.

Post-meridian Grits (*Canda-Galli and Schoharie Grits of New York*).—A formation containing two members hitherto only met with in a limited district in New York. The lower member is a dark-greenish argillaceous rock, recognisable by a peculiar plant, resembling somewhat a cock's tail. The upper member is a more calcareous grit. This formation is largely developed in New Jersey, north-east of the Delaware Water-Gap, where it has a thickness of 300 feet.

Post-meridian Limestone (*Upper Helderberg or Corniferous Limestone of New York, part of Cliff Limestone of Western States*).—In North-Eastern Pennsylvania, New Jersey, and New York, a blue, and in some portions a sparry limestone, including bands and nodules of chert. In Upper Canada and the Western States it is light-grey and straw-coloured, and sometimes oolitic, still retaining the chert. Among its many fossils are numerous large corals, as *Favosites Gothlandica, Favistella,* &c., and characteristic shells, as the *Pleurorhynchus trigonalis.* Its thickness east of the Delaware Water-Gap is about 80 feet.

CADENT SERIES.

Cadent Lower Black Slate (*Marcellus Slate of New York*).—A black and highly bituminous slate, graduating upwards into a dark-blue argillaceous shale. In some districts these are overlaid by greenish-grey sandy shales. In Pennsylvania, Virginia, and Tennessee, a thin argillaceous limestone generally occurs near the bottom of the black slate. The fossils, with few exceptions, are of diminutive size, most of them identical with those of the Cadent upper black slate. Thickness in Huntingdon, 250 feet.

Cadent Shales (*Hamilton Group of New York*).—Bluish-grey, brownish, and olive-coloured argillaceous shales, including in some districts thin beds of dark-grey and brown sandstone. It has many fossils, particularly bivalve shells. Thickness in Huntingdon, 600 feet.

Cadent Upper Black Slate (*Genessee Slate of New York*).—A brownish-black, and in some regions bluish-black, very fissile slate, characterised by its small and delicate fossils; many of them, as *Leptœna setigera,* identical with those of the Cadent Lower Black Slate. It is the lowest known horizon of *Carboniferous plants.* Thickness in Huntingdon, 300 feet.

VERGENT SERIES.

Vergent Flags (*Portage Flags of New York*).—A rather fine-grained grey sandstone in thin layers, parted by thin alternating bands of shale. It abounds in *marine vegetation.* Thickness in Huntingdon, 1700 feet.

Vergent Shales (*Chemung Group of New York*).—A thick mass of grey, blue, and olive-coloured shales, and grey and brown sandstones. The sandstones predominate in the upper part, where the shales contain many fossils. Thickness in Huntingdon, 3200 feet.

PONENT SERIES.

Ponent Red Sandstone (*Catskill Group of New York*).—In its fullest development this is a mass of very thick alternating red shales, and red and grey argillaceous sandstones. It has very few organic remains. Among them is the *Holoptychius,* and one or two other remarkable fossil fishes, of genera distinctive of Old Red Sandstone. This formation has its maximum thickness in its south-eastern outcrops, where it measures more than 5000 feet.

VESPERTINE SERIES.

Vespertine Conglomerate and Sandstone.—White, grey, and yellowish sandstone, alternating with coarse silicious conglomerates, and dark-blue and olive-coloured slates. It frequently contains beds of black carbonaceous slate, with one or more thin seams of coal. The only organic remains are fragments of coal plants; some of these are specifically, and even generically, different from those of the Seral coal series. It has its greatest thickness near the Susquehanna, where it measures 2660 feet.

UMBRAL SERIES, or CARBONIFEROUS SHALES and LIMESTONES.

Umbral Red Shales and Limestone.—In Pennsylvania this series consists almost entirely of soft red shales and argillaceous red sandstones, gradually becoming, in Virginia and Tennessee, a triple mass, the lowest member of which is a mass of buff, greenish, and red shales, with sandstones; the middle a thick body of light-blue limestone, often oolitic; and the upper, blue, olive, and red calcareous shales, embracing massive strata of grey and brownish sandstones. The limestone is the principal rock in the Western States. When it is a red shale it is without fossils, but as a limestone it is full of organic remains. The maximum thickness of the united Red Umbral Shale, south of the Southern Anthracite Basin, is 3000 feet.

SERAL SERIES, OR COAL STRATA.

SERAL CONGLOMERATE (*or Lowest Division of the Coal-Measures*).—A grey and whitish quartzose conglomerate, in massive beds alternating with grey sandstones. It frequently contains one or more thin seams of coal. It is thickest in the Sharp Mountain, where it measures 1100 feet.

LOWER PRODUCTIVE COAL-MEASURES; LOWER BARREN COAL-SHALES; UPPER PRODUCTIVE COAL-MEASURES; UPPER BARREN COAL-SHALES.—An exceedingly diversified group, consisting of these four subordinate formations. It comprises argillaceous and silicious sandstones, silicious conglomerates, shales of almost every colour and texture, and limestones both pure and argillaceous; all of these alternating with coal-slates and fire-clays, and numerous seams of coal. The organic remains are many species of terrestrial plants distinctive of the true Coal period; likewise marine shells, corals, and fishes.

CHAPTER II.

SUBDIVISIONS OF THE PALÆOZOIC REGION, AND BRIEF SKETCH OF THEIR STRUCTURAL FEATURES.

In describing the extensive and complicated region of the Palæozoic rocks of Pennsylvania, embracing nearly the entire State, it will be essential, for the sake of clearness, to subdivide the whole area into a number of subordinate districts, having natural boundaries, and to observe a definite order in the investigation of their details. I propose, therefore, to portion off the region into the following tracts :—

The Divisions of the Palæozoic region are,—

First, The South-Eastern District.—This embraces all the tracts of Palæozoic rocks in the south-eastern counties, including those of the South Mountain.

Second, The Kittatinny Valley District.—The long regular belt of the Kittatinny or Great Appalachian Valley.

Third, The Orwigsburg and Stroudsburg District.—This is the long and narrow zone of strata between the southern base of the Kittatinny Mountain and the southern base of the Pokono, and its prolongation, the Mahoning or Second Mountain, extending from Carpenter's Point to the Susquehanna.

Fourth, The North-Eastern District.—This embraces all the country N.W. of the division last mentioned, and N.E. of the Upper Lehigh, and of the North Branch of Susquehanna above the Lackawanna, omitting the Coal Basin, and includes the several valleys in Bradford and Tioga, which head south-westward between the detached table-lands of the bituminous Coal Basins.

Fifth, The Lower Juniata District.—This complicated belt of ridges and valleys is embraced between the Kittatinny Valley on the S.E., and the North Branch of Susquehanna below Berwick, Jack's Mountain, and Sideling Hill on the N.W. It includes the valleys east of the Main Susquehanna, known as Armstrong's Valley, Mahantango Valley, and the Valley of Roaring Creek, and that S.E. of the North Branch.

Sixth, The Upper Juniata District.—The scarcely less intricate parallel belt included between the North Branch, Jack's Mountain, and Sideling Hill on the S.E., and the foot of the Alleghany Mountain on the N.W.

Seventh, The North-Western District.—The tract to the N.W. of the bituminous coal district, embracing Crawford and Erie, with parts of Warren and Mercer counties.

Eighth, The Anthracite Coal District.—This includes not merely the interior of the several anthracite basins, but the mountain-belts encircling each, extending generally to the external base of the second or outer barrier.

Ninth, or Bituminous Coal District.—In this tract is embraced the whole of the bituminous region, including its insulated northern patches, and all the country to the N.W. of the Alleghany Mountain, excepting the portion already assigned to the Fourth and Seventh Districts.

GENERAL COMPOSITION AND STRUCTURE OF THE SEVERAL DISTRICTS.

First District.—It has been already fully shown in the first Part of this Work, that the only rocks of the Palæozoic system which appear in the south-eastern district, are those which appertain to the two lower series, the Primal and Auroral. These rocks appear in six separate belts.

The *First Belt* lies south of the Montgomery and Chester Valley; it is narrow at the Schuylkill, but expands south-westward, and from the Brandywine to York counties occupies nearly all the space between the valley and the State line. It contains the Primal slates and Auroral limestone, under conditions of excessive metamorphism. They are closely plicated with inversions, especially in the southern half of the belt; but it is possible to recognise and trace all the principal anticlinal and synclinal folds. This tract includes a succession of narrow oblique troughs of the Auroral limestone altered into crystalline marble. These are indicated on the Map. All the Palæozoic rocks are much intersected by cleavage planes and joints, and their true dip is therefore oftentimes obscure. They are, moreover, so transformed in many instances from their original sedimentary type, and resemble so closely the more ancient Gneissic or Hypozoic strata, with which they are in contact, that, from the vagueness of the dip, it is impossible to define their boundaries with due precision. The Geology of this diversified belt is discussed in detail in the text allotted to it; and for a general notion of it, the reader has but to study the Map and Sections.

The *Second Belt* is that of the long and narrow Valley of Chester and Montgomery counties, where the ridges immediately bounding the valley consist of the Primal slates and Primal white sandstone, and the bed of the valley itself of the Auroral magnesian limestone, all greatly altered by diffused igneous action. This belt begins at Trenton, includes only the altered Primal rocks as far as Willow Grove; but thence to Bart Township, Lancaster County, it embraces both this series and the limestone. The whole is a narrow synclinal basin, with the strata closely folded together, those of both sides of the trough dipping with much regularity to the S.S.E. at an angle ranging between 60° and 70°. (See the general and local Sections.)

The *Third Belt* is a short and slender tract of the Auroral limestone in Buck's County, near New Hope, where denuding action has cut through the comparatively shallow Mesozoic red sandstone, and exposed this small portion of its Palæozoic floor.

The *Fourth Belt* is the rather complicated one known as the Limestone Valley of Lancaster and York counties. Its boundaries are delineated on the Map; but the altered Primal slates, and the still older Gneissic rocks, are in some places so blended in their outcrops, and so similar in aspect, as to render their separation somewhat indefinite. This belt exposes the Primal slates, Primal white sandstone, and Auroral magnesian limestone, in a number of closely-compressed oblique anticlinal and synclinal flexures. (See the general Sections.) The prevailing dip is to the S.S.E.; only on the larger anticlinals do we meet with a dip to the N.N.W.; and in many of these the strata, in descending, steepen, and presently become inverted, dipping like the rest to the S.S.E. Within the belt there are four conspicuous anticlinal ridges, exposing the Primal white sandstone and a portion of the Primal slates: these are, Mine Ridge, Welsh Mountain, Chiques Ridge, and the Pigeon Hills. The Auroral limestone of this belt in the fertile region of the central part of Lancaster County has been extensively uncovered along its northern border by the denudation of the southern side of the shallow overlying red sandstone. Both the

Primal rocks and the Matinal limestone have undergone throughout many portions of this whole belt a partial metamorphosis, but their alteration has been less excessive than in the more southern belt of the Chester County Valley, and the district south of it.

The *Fifth Belt* is that of the South Mountains between the Delaware and Schuylkill, including Millbaugh Hill, near Womelsdorf. As shown by the Sections and by the Map, the Primal and Auroral rocks along this range occur in a succession of insulated tracts, the Primal sandstone forming, for the most part, the flanks and even crests of many of the hills, sometimes with a monoclinal outcrop reposing on the Gneissic rocks, sometimes in swelling anticlinals; while the limestone rests in the included synclinal valleys, and flanks, in some places, the belt on the S.E. The anticlinal and synclinal flexures affecting these rocks are, with few exceptions, of the *oblique* or *inverted order*, and therefore their prevailing dip is towards the S.E. The strata show fewer marks of extreme metamorphosis than those in the preceding belts.

The *Sixth Belt* is that of the South Mountains of Cumberland, Adams and Franklin counties. It includes only the Primal series, exposing extensively the Primal older slates, especially in the south-eastern ridges, for the most part greatly indurated, altered to a sub-crystalline texture, and affected by cleavage. The whole of the Primal series is here much thicker, and is more extensively expanded over the surface by numerous parallel flexures, than in the eastern South Mountains. The sections exhibit clearly the composition and structure of the belt, and show the anticlinals and synclinals to be of the oblique and much-compressed class, and the prevailing dip to be therefore towards the S.E.

Second District.—*Kittatinny Valley.*—The only formations which appear within the limits of this naturally-defined division of the Palæozoic region are those of the Auroral and Matinal series; nor are all of these continuously or extensively developed, the principal masses being the Auroral magnesian limestone and the Matinal newer slate. The Auroral calcareous sandstone at the bottom of the series is but seldom seen, and it is only occasionally that we observe at the junction of the limestone and slate along the middle of the valley the other two formations, the Matinal argillaceous limestone and Matinal black slate. They would seem not to have been everywhere deposited so far to the S.E. The Matinal black slate occurs in a very narrow outcrop in Northampton and Lehigh, and the Matinal argillaceous limestone is occasionally in contact with it in the same region, and appears again in Franklin County. This latter is almost the only formation of the whole belt which is obviously *fossiliferous,* the others being very scantily supplied with organic remains.

In its geological constitution the Kittatinny Valley displays remarkable uniformity. Excepting in the south-western part of Franklin County, the whole belt is composed of two great lithological zones, the Auroral magnesian limestone forming its south-eastern side, and the Matinal upper slate its north-western.

In the part of Franklin just referred to, these two formations repeat themselves in several short and narrow parallel anticlinal and synclinal outcrops. Through the entire length of the valley the strata are folded into a very uniform steep south-eastern dip, in a series of compressed flexures. This structure is distinctly illustrated in all the numerous general sections which cross the district. It is only by a careful and minute inspection of the phenomena of the dips that the geologist detects in this greatly plicated belt the lines of anticlinal and synclinal flexure. These he cannot, however, ultimately fail to recognise, after due practice. They are readily discernible on the Delaware, Schuylkill, and Susquehanna, and on the Cumberland Valley Railroad. In the zone of Matinal slate the flexures are more obscure than in the limestone, in consequence of the excessive amount of cleavage which, though it affects the limestone, is a more prevailing feature of the slate. The almost universal direction of dip in the cleavage planes is S.E., or parallel with that of the stratification, or more strictly with the dip of the imaginary planes bisecting the anticlinal and synclinal curves or flexures. These cleavage planes in the slate, more especially, often efface all marks of the original bedding, and render the detection of the few organic remains of the strata very difficult. Along the north-western border of the valley the beds of slate have their normal dip, inclining north-westward beneath the sandstones of the Kittatinny Mountain; but along its south-eastern margin,—so general is the *inversion* of the folded limestone,—this formation appears almost everywhere to pass under the Primal rocks of the South Mountains; and were we not familiar with this striking and general fact of the close compression and obliquity of the more south-eastern Appalachian flexures, and had we not fully established the true infra-position of the Primal to the Auroral rocks, we might imagine the latter to be the lower or older group.

Third District.—*Orwigsburg and Stroudsburg Valley.*—This long and very narrow tract consists of the Levant, Surgent, Pre-meridian, Meridian, Post-meridian, Cadent, Vergent, and Ponent Rocks, embraced between the south-eastern base of the Kittatinny Mountain and the foot of the Pokono and Second Mountain. Between Carpenter's Point and the Walpack Bend of the Delaware, we have only the Cadent and higher strata on the Pennsylvania side of the river; but between the Walpack Bend and the Water-Gap, the Post-meridian, Meridian, and Pre-meridian Rocks enter the State from New Jersey, and near the Water-Gap the whole of the Levant series gradually crosses the river. From this point to the Susquehanna, all the formations enumerated are included within the belt.

The structure of the tract is by no means intricate. From Carpenter's Point to the Walpack Bend, the strata have all a gentle N.W. dip; but south-westward from that locality, the belt contains in most places one principal anticlinal flexure, and in certain localities there are lesser ones parallel with it; but even the main anticlinal does not range the whole length of the tract, for that which is the chief axis between the Delaware and the Little Schuylkill, leaves it, and passes into the Pottsville Coal-basin, south of Middleport, while another takes a nearly corresponding place, entering it from the side of the Kittatinny Mountain. This last dies out near the Swatara, and from thence to the Susquehanna the dip is monoclinal and very nearly perpendicular, becoming even inverted as we approach the river. The general sections exhibit sufficiently the structure of the belt in each different segment of its length.

Fourth District.—*The North-Eastern Counties.*—Throughout this extensive district we are presented with very little variety, either in the strata, their mode of dip, or the features of the surface. Between the south-eastern escarpment of the Pokono Mountain, and the northern line of the State, nearly the whole region, if we except the Lackawanna Coal-basin, and the mountains enclosing this trough, is a high and much undulated table-land, the south-westward expansion of the plateau of the Catskill Mountains, with only a few defined ridges and chains of hills upon it. Its strata belong chiefly to the Ponent series, one of the least fossiliferous, least useful, and least interesting of all our Appalachian formations. They are spread out in a succession of very flat and wide synclinal and anticlinal waves, as exhibited in Section I., and are therefore approximately horizontal.

This district includes the four anticlinal valleys in Bradford and Tioga, which divide the several narrow plateaus in which the bituminous coal-basins terminate towards the N.E. These anticlinal belts expose no strata lower in the scale than the Vergent flags and Vergent shales which saddle each axis. The other rocks are of the Ponent series, and have their outcrops around the borders of each valley. The general sections exhibit the broad undulations of this region.

Fifth District.—*The Mountain-belts of the Lower Juniata.*—The rocks exposed in this very complicated division of the Appalachian Chain, included between the Kittatinny Mountain on the S.E. and Jack's Mountain on the N.W., consist of all the great series of strata from the Auroral to the Ponent inclusive. A sufficiently correct general conception of the structure of the district will be derived from a comparison of the Map with the general Sections, and by observing that the whole region is made up of three great anticlinal belts, each consisting of a group of several lesser undulations, and of four synclinal tracts, likewise compound, but showing fewer flexures.

The *First Anticlinal Belt* is that of Perry County. It commences in the Pottsville Coal-field, on the Swatara, divides the two western prongs of the basin, and is the anticlinal, separating Berry's and Peter's mountains. It lifts, within the limits of our present district, the Ponent and Vergent rocks in Powell's and Armstrong's valleys, and crossing the Susquehanna, elevates the Cadent rocks in the Half-Fall Mountain. Soon after crossing the Juniata, it ceases to be a nearly simple anticlinal belt, and becomes a group of parallel flexures, rapidly widening by the successive introduction of new anticlinals. These, as we trace the belt in its gradual sweep south-westward, diverge and elevate to the day in the central part of the general tract of Cadent strata, first the Pre-meridian, and next the Surgent rocks, showing lower and lower strata as we advance, and imparting to each formation a complicated but beautifully winding line of outcrop. The more south-eastern of these anticlinals pass out early into the Kittatinny Valley, the more north-western range through Amberson's Valley, but also enter the Kittatinny near Loudon.

The *First Synclinal Belt* is the broad trough of Vergent, Ponent, and Vespertine rocks west of the Susquehanna, and embraced between this anticlinal zone and the southern basin of the Kittatinny Mountain, and called Sherman's Creek Valley. It is the trough of the Dauphin Coal-basin.

The *Second Anticlinal Belt* is that of Mahantango Valley, Tuscarora Mountain, and Path Valley. This originates as a group of flexures in the north-western part of Broad Mountain, and within the district before us lifts to the surface the Ponent, Vergent, and Cadent Rocks in Mahantango, and crossing the Susquehanna, brings to view in the great anticlinal of the Tuscarora Mountain, the Meridian, Pre-meridian, Surgent, and Levant strata to the Levant White Sandstone. Advancing and curving south-westward, the belt develops other parallel anticlinals in Liberty Valley, which, passing through the knobs of the Southern Tuscarora Mountain, and the "Locking of the Mountains," enter North Horse Valley, and expose the Matinal slates. As these decline others rise, and a chief one ranges along Path Valley, bringing up the Auroral limestone. Connected with this belt is the anticlinal of M^cConnellstown Cove.

The *Second Synclinal Belt* is that of Wildcat and Buffalo Creek Valleys. It is the westward prolongation of the trough of the Bear Valley Coal-basin. It is a nearly simple synclinal trough, containing, west of the Susquehanna, the Vespertine, Ponent, Vergent, and Cadent strata. By the coalescing of the first and second anticlinal belts it terminates near the head of Buffalo Creek.

The *Third Anticlinal Belt* is that of Shamokin Valley, and Shade and Black Log Mountains. It is a more simple anticlinal zone than either of the preceding. The flexures which compose it begin near the Lehigh River, and are traceable between the basins of the Eastern and Middle Coal Region, and through the Catawissa Valley into Roaring Creek Valley in the district before us. In the valley of Roaring Creek and Shamokin Creek, the rocks exposed in this zone are the Ponent, Vergent, and Cadent. Soon after passing the Susquehanna, the Pre-meridian, and next the Surgent and Levant strata, rise to the day upon the expanding anticlinal of the Shade Mountain, which, for some distance, is the only flexure of the belt. Approaching the Juniata, as this anticlinal begins to subside, another conspicuous one, that of Blue Ridge, rises, and parallel with it a second, still greater one, that of Black Log Valley. The first lifts the Levant White and Red Sandstones into a mountain-ridge with a double crest, while the last-named elevates first the whole Levant series, and then the Upper Matinal Rocks in the anticlinal valley of Black Log. This latter grand wave upon the crust continues further south than that of Blue Ridge, and dies away soon after entering Fulton County, the whole belt there terminating by the closing over of the Ponent strata. The anticlinal of Pigeon Cove, at the Maryland line, may be referred to this belt, or the second, indiscriminately.

The *Third Synclinal Belt* is the long and regularly-curving valley bounded by the second and the last-described anticlinal belts. Where it is crossed by the West Mahantango and Cocolamus creeks, it is a broad valley of the Vergent and Cadent rocks; but approaching the Juniata, anticlinal undulations elevate the Surgent and Scalent marls and shales, and the zone of Vergent and Cadent strata is contracted to the narrow central valley of Tuscarora Creek. The belt continues through the little Aughwick Valley of the same narrow dimensions. To this synclinal zone we may refer the trough of Scrub Ridge, in Fulton County.

The *Fourth Synclinal Belt* is embraced between the third anticlinal and the foot of Jack's Mountain, Montour's Ridge, and Sideling Hill, the north-western limits of the district. This long and narrow trough in the strata is traceable from the knob of Catawissa Mountain, as a hilly zone of the Ponent rocks following the North Branch, and extending westward towards New Berlin. Curving with an ample sweep more and more to the south, the valley, now confined between Jack's Mountain, Shade Mountain, and Blue Ridge, includes a series of small anticlinals, which lift the Surgent rocks, so that this part of the belt exposes a chain of several parallel outcrops of the Vergent, Cadent, Pre-meridian, Surgent, and Levant strata, as far to the S.W. as the Great Bend of the Juniata. Beyond this point the belt is of simpler structure, the minor anticlinals subside, and the trough contains little else than the Vergent and Cadent rocks to the termination of Jack's Mountain. From this latter locality to the southern line of the State, this zone becomes monoclinal along the foot of Sideling Hill, showing the Vergent and Ponent rocks dipping gently westward, first from the Jack's Mountain anticlinal, and then from that of Pigeon Cove.

In relation to the character of the flexures in this diversified Fifth District, very few words of general description will suffice. Nearly all the undulations, both the greater and the lesser ones, are bold curves of the normal type, that is to say, have their north-western sides steeper than their south-eastern, but not *inverted*, as in the district of the Kittatinny Valley, nearer the source of the pulsations of the crust which caused the flexures. The special features of each zone will be found distinctly delineated in the numerous general and local sections which cross the whole district; and their geology will be treated of in detail in future chapters.

Sixth District.—*The Mountain Belts of the Upper Juniata and West Branch of the Susquehanna.*—In the complicated division of the Palæozoic region, to which we next proceed, we have repeated and extensive outcrops of all the strata from the top of the Ponent to the bottom of the Auroral series. The general sections from IV. to IX., inclusive, cross the district, and, if studied in connection with the Map, will much assist the reader in comprehending the following outline. Looking at the structure of the whole district, we perceive it to consist of six natural lesser belts or tracts, but not disposed in an order as regular and parallel as those of the district just described.

The First Belt is embraced between the southern part of Montour's Ridge and the base of the Alleghany Mountain, and extends lengthwise from east of Harvey's Creek to the western ends of Buffalo, Whitedeer, and Whitedeer Hole valleys. The rocks comprised within the tract are those of the Levant, Surgent, Pre-meridian, Cadent, Vergent, and Ponent series. On the S.E. the interesting anticlinal zone of Montour's Ridge shows all the Surgent and Upper Levant strata. North of it runs the long synclinal of the Vergent and Ponent rocks, investing the western end of the Wyoming Coal-basin; and north of this again there is a long anticlinal tract, crossing the upper waters of Harvey's and Fishing creeks, and elevating the same series. In the central portion between Montour's Ridge and the end of the Bald Eagle Mountain, the Surgent and Pre-meridian rocks appear in the region around Milton, with a belt of the Cadent and Vergent both north and south of them. West of the Susquehanna this belt is limited by a succession of symmetrical anticlinal mountain-spurs, the terminations of as many great anticlinal waves, which there lift in gentler undulations the Middle and Upper Levant, Surgent, and Pre-meridian strata through the Cadent and Vergent, and impart to the Surgent a very winding line of outcrop, folding this series round the points of the mountains and into the coves, or intervening synclinal valleys.

The Second Belt is the well-characterised region embraced between Jack's Mountain and the Bald Eagle Mountain. It includes a very remarkable group of grand anticlinal flexures, the top of each principal wave forming a long and narrow fertile valley of the Auroral limestones and Matinal slates, divided by bold synclinal mountain-ridges of the massive Levant sandstone. The larger valleys are Kishicoquillas, Penn's, Brush, Sugar, and Nittany valleys. These close at one or both ends by the gradual coalescing of their mountain-barriers, brought together by the declension of the crests of the anticlinal waves. Ten long symmetrical mountain-spurs of the Levant white sandstone, curiously arranged in echelon, form the eastern termination of this belt. Its western end is near the Juniata, in the two anticlinals of Jack's Mountain and Bald Eagle Mountain, not far from Hollidaysburg.

The Third Belt is an interesting synclinal zone nearly in the prolongation of the former, commencing on the N.E. between the two southern terminating anticlinals, and having Tussey Mountain for its north-western boundary, and Stone Mountain and the base of Sideling Hill for its south-eastern. In this deep and broad trough in the strata, which consists in the main of but one ample synclinal basin, with a few lesser undulations, there are contained the whole of the Palæozoic strata of the State, from the Levant sandstones to the Coal strata inclusive, excepting only the Post-meridian series, universally absent to the S.W. of the Delaware River. In the limited Coal-basin of Broad Top Mountain, we have an outlying patch of bituminous coal-measures, denoting not only the depth of this great synclinal wave, but in its remoteness from the main coal region W. of the Alleghany Mountain, the enormous extent of the denudation which the intervening anticlinal belt of country has experienced.

The Fourth Belt is the narrow anticlinal zone in Huntingdon and Bedford, bounded on the east by the eastern base of Tussey Mountain, and on the west by the north-western foot of Dunning's and Wills' Creek mountains. This tract embraces a chain of fertile anticlinal valleys of the Auroral limestone, namely, Morrison's Cove, Friends' Cove, Bean's Cove, and Milliken's Cove ; the three first forming the back of a great anticlinal wave, or perhaps more strictly of a group of waves. In the central parts of Morrison's Cove, as in the corresponding parts of the Kittatinny Valley, the crest of the anticlinal wave exposes the very lowest sandy strata of the Auroral series, the equivalents of the Auroral calcareous sandstone (Calciferous Sandstone of New York). On the other hand, rocks as high in the scale as the Meridian sandstone rest in the synclinal trough between Evit's and Wills' Mountain.

The Fifth Belt is the very long and narrow and continuous valley enclosed between the Bald Eagle, Dunning's, and Wills' mountains, on the S.E., and the escarpment of the Alleghany Mountain on the N.W. This zone possesses, except where a few local undulations occur, a very regular monoclinal structure, its strata dipping towards the N.W., at an angle which grows progressively less as we advance in that direction and ascend in the general series. Its rocks, commencing with those on the north-western flank of the Bald Eagle range, and terminating near the summit of the escarpment of the Alleghany, appertain to the Surgent, Pre-meridian, Meridian, Cadent, Vergent, and Ponent formations. Only in the western side of Bedford County are the simple monoclinal features of this long valley locally interrupted by the introduction of two or three small anticlinal tracts. Throughout the extensive and varied Sixth District, the anticlinal and synclinal flexures of the strata are of great length and striking parallelism, and in many quarters so singularly regular, as to suggest irresistibly their analogy to a group of stupendous waves or billows in a flexible crust. It will be seen by a glance at the sections which illustrate this district, that the flexures are, with scarcely an exception, of the normal order, but have, like those of the Fifth District, a large arc of curvature, and therefore a prevailing steepness in their dips. In a few instances, a longitudinal dislocation of the strata is discernible along the crest, or on the north side of the anticlinal waves ; and usually in such cases there is a sudden change in the dip, with a loss of regularity in the form of the anticlinals.

Seventh District.—*The Country N. W. of the Bituminous Coal Region.*—This division of the Palæozoic region of the State is, as the Map shows, of an irregular, triangular form, being but a portion of an extensive natural geological belt, which ranges from southern New York into north-eastern Ohio. In stratification and structure, it is by far the simplest portion of the State. The only formations which underlie it are the Vergent shales and the Vespertine sandstones, for it is an interesting fact that both the Ponent red sandstones and shales, and the Umbral red shale, are entirely thinned away before they reach this north-western outcrop of the general basin, enormous as their thickness is in the south-eastern valleys of the Appalachian Chain.

By the general section (VIII.) it will be seen that across this whole tract the strata exhibit, with little or no variation, an extremely gentle dip towards the S.E., passing finally under the Bituminous Coal Region. From the north-western outcrop of the Lower Coal Rocks, the surface gradually slopes north-westward to Lake Erie, descending about 1000 feet.

Eighth District.—*The Anthracite Coal Region.*—This is a division of the Appalachian Chain, of great apparent complexity of structure, but of remarkable and beautiful symmetry when understood. I include in it not only the Coal strata or Seral series, but the Umbral and Vespertine formations also, and therefore its curiously inflected boundary will be traced by following the outer base of each external or second mountain encompassing the Coal-basins and valleys of Umbral red shale. In the aggregate, it may be viewed as a broad synclinal tract enclosed between the anticlinals of the Kittatinny Valley on the south, and the wide anticlinal at the foot of the Alleghany Mountain on the north; but regarded more in detail, we find it composed of an extensive succession of moderately steep anticlinal and synclinal flexures or waves arranged in several groups or belts.

The First Belt is that of the Pottsville or southern coal-basin. This is a long synclinal zone beginning E. of the Lehigh in the Kettle Mountain, and terminating W. of the Susquehanna in the two troughs of the Cove and Buffalo mountains. This synclinal belt forks into two at the knob of Berry's Mountain, where a great anticlinal flexure elevates lower rocks. In the interior of this great trough, or the part occupied by the coal strata, there are several subordinate undulations of the strata producing important local effects in the distribution of the coal-beds, but unconnected with any very conspicuous features of the surface. The Coal-basin itself reposes in the middle of the general synclinal zone of the Umbral red shale, and Vespertine conglomerate. It begins at the Lehigh, gradually widens to a breadth of four miles at Pottsville, and at Good Spring Creek divides into the two basins of Dauphin and Bear Valley. A more detailed description will be given in the chapters on the Anthracite Coal strata.

The Second Belt is a shorter parallel anticlinal tract extending from the Lehigh westward, next north of the Pottsville Basin. It comprehends, first, the Nesquihoning Broad-Mountain, composed of Vespertine conglomerate; next, the Locust Valley of Umbral red shale; and, lastly, Broad-Mountain, a table-land consisting of the Seral conglomerate, with a few subordinate narrow basins of the Coal-measures. This belt ends westward in the concave sweep of the Mahantango Mountain. Broad-Mountain is an elevated plateau, including several lesser anticlinals, which pass out into the low valleys of the Umbral red shale, both eastward and westward, by a series of loops which separate its synclinal mountain-spurs. The structure of the Nesquihoning Mountain is that of a wide, flat, regular anticlinal wave, w ith a number of insignificant gentle undulations on its summit and northern flank.

The Third Belt is the important synclinal tract or basin north of Broad-Mountain, which contains the rich coal-fields of Mahanoy and Shamokin, or the *Western Middle Coal-basins.* It commences in the Head Mountain, and terminates westward at the Susquehanna, in the synclinal knob of Mahanoy Mountain. The inner trough, or that of the Coal strata, comprehends several lesser basins divided by well-defined anticlinal ridges.

The Fourth Belt is the broad table-land including the *Eastern Middle Coal-basins.* It lies between the anticlinal belt of Nesquihoning Mountain on the S., and that of the Wapwallopen and North Branch on the N., and extends from near the Lehigh westward, to the western foot of the Catawissa Mountain. Its central plateau of the Seral conglomerate comprises five continuous and well-marked anticlinal flexures of gentle curvature and dip, forming six small and shallow troughs of the Coal-measures. The terminations of some of these minor basins are discernible in the flat mountain-spurs, which protrude eastward and westward from the general plateau.

The Fifth Belt is that of the beautiful and well-defined Wyoming Coal-basin. As all the other belts are severally in contact with each other, so is this one linked to the last described by the high table-land of the Vespertine conglomerate between the sources of the Lehigh and Wapwallopen. This belt is a very regular synclinal trough, tapering to a point at each end, and sweeping with a bold crescent curve, convex towards the S.E. The Coal-measures, as in all the other synclinal tracts, are encompassed by a double mountain-crest, the interior consisting of the Seral conglomerate, the exterior of the Vespertine sandstone. Within the Coal-basin there are several secondary undulations imparting no prominent features to the tract, but affecting materially the local outcropping of the coal-beds. The belt, including the Vespertine strata, originates a few miles N. of Carbondale, and gradually curving south-westward and westward, terminates in a synclinal mountain-ridge at Fishing Creek.

A general survey of the relative positions of these several belts of the Anthracite districts, as they are depicted on the Map, discloses a curious oblique arrangement. Each more northern zone is situated further east than its neighbour. In other words, all the principal anticlinal and synclinal flexures of the region are grouped in echelon.

By consulting the general sections which cross the district, it will be seen that only in the first, or Southern Coal-basin, do the flexures approximate to the folded or inverted type. Advancing northward, the undulations take on the normal form, and decline progressively in curvature or steepness as we proceed. In the Western Middle Coal-basin the strata dip at a moderately high angle; while in the more northern tracts of the Eastern Middle, and the Northern or Wyoming belts, they undulate much more gently. This striking gradation is but one instance, among many, of conformity to a law which is very general throughout the entire Appalachian Chain, namely, that the undulations of the strata open out and decline in steepness as we recede from the quarter of maximum disturbance or rupture of the crust, precisely as we see occur in the more advanced waves of a broad group of billows suddenly generated upon the surface of a fluid by some local force.

Ninth District.—*The Bituminous Coal Region.*—In its composition and structure, this last, and much the largest, of all the divisions of the general Palæozoic region of the State, is extremely simple. It comprises only the Vespertine, Umbral, and Seral series, the former in very narrow lines of outcrop, bordering and dividing some of the coal-basins, except in the north-eastern part of the district, where the Vespertine conglomerate, or sandstone, occupies an extensive irregular area between the escarpment of the Alleghany Mountain on the S., the State line on the N., the valley of the North Branch of Susquehanna on the E., and the waters of the Sinnemahoning on the W. Throughout the rest of the region, the Coal-measures bordered by the Seral conglomerate occupy the whole surface. The beautifully symmetrical structural features of this vast region are illustrated in the general Sections. Viewed broadly, the whole territory is to be regarded as only the north-eastern end of an enormous coal-basin, which, commencing in our northern counties, has its southern termination in Middle Alabama. The portion which is embraced within the limits of Pennsylvania, covers more than 10,000 square miles. It has for its south-eastern margin, the narrow table-land of the Alleghany Mountain; and for its northern border, the much wider plateau of the northern counties. From these two limits, the surface slopes south-westward, sinking gradually towards the middle of the vast but nearly horizontal trough.

Traversing nearly the whole length of this district are five very long and comparatively low or flat anticlinal undulations, which subdivide the general area into six subordinate narrow coal-basins.

The *First* of these lesser basins is bounded in Somerset by the anticlinals of Negro Mountain and Laurel Hill. It thence follows the table-land of the Alleghany Mountain, and ends at the North Branch in the narrow plateau of the Mahoopeny Mountain, the trough gradually ascending and flattening until finally it is greatly denuded of its coal-measures, as it approaches its north-eastern termination.

The *Second Basin*, or that of Ligonier Valley, is in its southern parts a deep trough, between the anticlinals of Laurel Hill and Chestnut Ridge. It rises and shoals towards the N.E., and as a continuous coal-basin terminates on the West Branch of the Susquehanna, below Karthaus. Further on it becomes a table-land, ending in a narrow elevated spur near Towanda, and sustaining, like the eastern end of the first basin, only a few detached small patches of the coal-rocks.

The *Third Basin* begins near the Kiskiminetas, and rises toward the Sinnemahoning, until at Trout Run it ceases to contain a continuous belt of the Coal-measures. It there merges into the general northern plateau, and is prolonged into Bradford as a third narrow mountain-spur, sustaining a few insulated tracts of the Coal strata. South of the Kiskiminetas there are three sub-basins in the prolongation of this third synclinal belt.

The *Fourth Basin* likewise commences near the Kiskiminetas, and ceases to hold any but a few small patches of Coal strata beyond the sources of Trout Run. It ends in a long narrow plateau or flat spur in the northern part of Tioga County.

The *Fifth Basin* originates as a defined trough of the Coal-rocks in the neighbourhood of Freeport, by the rising of the anticlinal axis which forms its north-western limit. This basin contains an unbroken belt of Coal-measures as far as Clarion River. Following the valley of that stream toward its sources, it becomes a part of the general northern table-land. Though it retains the synclinal form, only its higher summits hold any tracts of the Coal strata, and even these scattered patches cease after the belt enters Potter County some distance. Its north-eastern prolongation is rather a chain of low, flat, sandstone hills, than an unbroken spur or plateau. South-westward it merges into the larger basin of the Ohio River.

The *Sixth Basin* is the last or north-western trough, formed by the general south-eastward dip of all the strata from their north-western outcrop, and by the fifth anticlinal. It is of great breadth in Butler, Beaver, and Mercer, but contracts and grows shallow in Clarion and Elk, and becomes a mere chain of detached coal-bearing summits resting on an elevated plateau of the Seral and Vespertine sandstones and conglomerates, as it ascends the Tionesta into Warren and McKean counties. In the opposite or south-western direction, this trough enlarges by the merging into it of some of the narrow adjacent basins on its S.E., and it becomes the main coal-field of the Ohio River for a great distance along the western border of Virginia and the south-eastern side of Ohio.

Besides the above six long subordinate troughs included in the general Coal-field, there is one to the east of the first enumerated, occupying the south-eastern side of Somerset County, between the anticlinal axis of Negro Mountain and the crest of the Alleghany Mountain. The northern end of the Potomac Basin of Virginia and Maryland penetrates a few miles into Pennsylvania.

There is a small high synclinal belt, containing, however, little or no available coal, in the table-land of the Alleghany or Bowman's Mountain, in Luzerne County. This may be viewed as a portion of the first or Mahoopeny Basin.

Taking a comprehensive view of the whole broad bituminous Coal region, we are struck with the extraordinary length, parallelism, evenness of breadth, and progressive declension north-westward of its several beautiful belts of symmetrical, anticlinal, and synclinal waves, and with their strong resemblance, in all the features here named, and in their grand crescent-like sweep, to a group of subsiding billows.

When we enlarge our survey still farther, and embrace the entire width of the Appalachian flexures from the south-eastern to this north-western side of the State, we are still more forcibly impressed with this resemblance, and with the appropriateness of the general theory of crust-undulations elsewhere given. In the south-eastern division of the State, the strata are, for the most part, closely folded or plicated, the north-western sides of the anticlinals being entirely *inverted:* in the middle or mountain region, this feature is somewhat subdued; the waves are more expanded, though still steep and of the unsymmetrical form; while in this north-western district, the undulations are low, and much dilated, and the two slopes of each wide wave are approximately equal.

CHAPTER III.

DISTRIBUTION OF THE PALÆOZOIC STRATA IN PENNSYLVANIA, AND THEIR CHANGES OF TYPE AND THICKNESS.

Before entering on the detailed delineation of the Palæozoic Rocks, in their many successive outcrops within the State, it will be expedient, for the sake of completing our general picture of them, to show their broader features, with the changes of type and thickness which they undergo. Beginning with the lowest, and pursuing each formation in the geographical order laid down, or from S.E. to N.W., we shall commence with the Primal series.

PRIMAL SERIES—South of Chester Valley.

Primal Lower Slate.—This formation is developed in great thickness from the Brandywine to the Susquehanna, and thence south-westward, but is too much disguised by metamorphism, and close plication of its beds, to admit of measurement. It is, indeed, nowhere susceptible of exact estimation, but may be conjectured to be, where most expanded, ... 2000 feet.

Primal Sandstone.—This rock, the equivalent of the Potsdam Sandstone of New York, is distinctly visible, though not in much thickness, around some of the small limestone basins of Chester County. It is prominent on the Street Road, and in Dochranaman Hill; but its thickness is not accurately ascertainable. It occurs on the Susquehanna, the most southern outcrops being near Peach Bottom, where it measures . 90 „

Primal Upper Slate.—This formation is not recognisable around the limestone troughs of the southern part of Chester County.

The Primal Lower Slate,—

On the Schuylkill, consists of two divisions :—

1st, *The Lower,* a semi-porphyroidal altered sandy slate, is . . . . . 300 „

2d, *The Upper,* an imperfectly crystallised talcose micaceous slate, is . . . . 200 „

In Edgehill, near Attleborough, the formation measures . . . . . . 200 „

Primal Sandstone.—This frequently consists of two sandstones and an interposed slate.

Thicknesses—

On Schuylkill and Wissahickon, 35 to		40 „
East of Willow Grove (including quartzose conglomerate),		100 „
Edgehill, near Attleborough,		300 „
Coatesville, North Valley Hill—		
Lower Sandstone,	15 feet.	
Slate,	70 „	
Upper Sandstone,	40 „	
		125 „
Parkesburg, North Valley Hill—		
Lower Sandstone,	50 „	
Slate,	300 „	
Upper Sandstone,	20 „	
		370 „
Susquehanna, above Columbia—		
Lower Sandstone (with included bands of slate),	300 „	
Slate,	300 „	
Upper Sandstone,	27 „	
		627 „

Primal Upper Slate—in line of Chester Valley.

At *Willow Grove*, and east of it, this rock does not exist.	
In *Barren Hill*, and on the North Pennsylvania Railroad, it is talcose and thin.	
At the *Diamond Rock*, and in Paoli Section, it is thin, possibly between 200 and	300 feet.
Near *Coatesville* it is	700 „
At *Parkesburg*, where probably all is not seen, it shows	300 „
On the *Susquehanna*, above Columbia, it measures about	1000 „

From the above data it would appear that this division of the Primal series augments even more rapidly than the White Sandstone as it stretches westward.

Survey of the Formation—The Primal White Sandstone fluctuates much as to its thickness within the region where it occurs, though it is singularly retentive of its character as a rock. It would seem on the whole to augment towards the S.W. or W.; and this agrees with its general absence in New Jersey, and its full dimensions on the western slope of the Blue Ridge in Virginia.

The Primal Upper Slate likewise increases westward and north-westward, as the preceding statements fully indicate. We know, moreover, that it is in great force in Maryland and Virginia.

PRIMAL SERIES—in the South Mountains.

On the *Delaware River*—

The Primal Sandstone is the principal formation of the series, very little slate being discernible.	
In *Durham Ridge*, at Myer's Quarry, its whole thickness is about	100 feet.
In *Chestnut Hill*, north of Easton, the sandstone is well developed, but its thickness is unknown; probably it does not exceed	100 „

On the *Schuylkill*, below Reading—

Its thickness is much greater than at the Delaware.

It is folded and crushed, and cannot be measured.

The Primal Slates possess some development in the South Mountains near the Schuylkill, but cannot be measured.

In *Adams County*—

Both of the *Primal Slates*, particularly the Lower, are evidently largely developed in the South Mountains, between the Susquehanna and the Potomac.	
The Primal Sandstone is also thick throughout this belt, probably as thick as on the Susquehanna, or	300 „
The Primal series nowhere rises again to the day N.W. of the South Mountains.	

AURORAL SERIES.

Auroral Calcareous Sandstone.—A rock apparently identical with the true Calciferous Sandstone of New York, is visible near the Delaware, and at a few points further W., along the south margin of the Kittatinny Valley, as at Columbia, but nowhere throughout this belt in much thickness. Assuming that the lowest sandy Magnesian Limestone of the Auroral series at *Columbia* represents this formation, it has there a thickness, between the underlying Primal slate and another overlying slate, of 250 feet.

No fossils having been discovered in it, we have only lithological characters to guide us, and its identification is therefore doubtful.

A calcareous friable sandstone, unlike the Primal sandstone, rises from beneath the Auroral limestone in the more elevated tracts of *Nittany Valley* and *Morrison's Cove*, and I have less hesitation in referring it to the Auroral calcareous sandstone. Still no fossils have been found in it, though no favourable outcrops have occurred.

AURORAL MAGNESIAN LIMESTONE.

This great formation, which seems to constitute the most extensive floor of the Appalachian Basin east of the Missouri River, is nowhere in Pennsylvania susceptible of entire measurement. In its south-eastern synclinals, as the Chester and Conestoga valleys, we have its lower part, but not its upper. In the Kittatinny Valley, though the whole formation is present, it is too much plicated and obscured to admit of satisfactory mensuration; and in the great anticlinal valleys of Centre, Blair, and Bedford, though its entire thickness outcrops in certain neighbourhoods, it is impossible, from the extensive wash from the sandy barrens against which it rests, to ascertain, within a few hundred feet, its lower limit. In these last districts we may, however, make an approximation to its total bulk.

On the *Schuylkill* its upper and lower portions are not visible, or are so concealed as to make estimation of thickness impossible. It is, however, practicable to obtain proof of great thickness, by measuring across the limbs of the synclinal basin from its contorted central area. The measurements thus made serve to check each other, and give a thickness of 3000 feet, comprising evidently the middle and a large part of the lower beds of the formation. The limestone is of the Magnesian type, somewhat argillaceous in the upper beds.

In *Kishicoquillas Valley* the lower beds are not visible for perhaps many hundred feet.

1.	The lowest seen are alternations of light-blue, fine-grained, and darker magnesian rock, with knots of white dolomite,	300 feet.	
2.	Fine-grained light-greyish blue magnesian limestone,—a little chert in lower layers,	600 „	
3.	Dark crystalline magnesian limestone, with kernels of dolomite,	100 „	
4.	Light-blue limestone, weathers mealy, conchoidal fracture,	600 „	
5.	Slightly magnesian limestone, some beds very pure; fine texture, purplish blue, massive and ribboned,	200 „	
6.	Pure light-blue conchoidal and massive limestone,	150 „	
	Total thickness visible,		1950 feet.

Nittany Valley, Bellefonte, ascending—

1.	Grey crystalline rough magnesian limestone, underlaid by much of same containing chert, visible,	600 „	
2.	Pure blue limestone—no fossils,	700 „	
3.	Grey crystalline limestone, no fossils,	1500 „	
4.	Light-blue fine-grained, like bird's-eye marble, a very few characteristic fossils,	300 „	
5.	Alternation of light and dark-grey rough crystalline rock, weathers with sandy surface (not silicious), corals and other fossils,	1000 „	
6.	Magnesian, massive light-blue grey—no fossils,	500 „	
7.	Alternation of blue coralline and argillaceous dull-blue magnesian limestone,	200 „	
8.	Dark-blue massive rubbly limestone, with many fossils,	400 „	
9.	Clear blue, massive, like bird's-eye marble, with fossils,	150 „	
10.	Massive, blue, fine-grained limestone, with obscure corals,	20 „	
11.	Blue, thin-bedded limestone, encrinal and coralline,	30 „	
	Total thickness,		5400 feet.

MATINAL SERIES.

The Matinal series is evidently thick wherever it appears in Pennsylvania, and has apparently its maximum dimensions at its great south-eastern outcrop, in the Kittatinny or Appalachian Valley. There, however, its thick uppermost mass, the Matinal shale, is unfortunately so folded and so intersected with cleavage-planes as to baffle every attempt at measurement. The whole series cannot be of much less depth than the Auroral limestone, and we shall not err widely if we assume it, in the Kittatinny Valley, at from 3000 to 4000 feet.

The Matinal shale manifestly declines in thickness as it spreads north-westward, but the other members—the black slate and the argillaceous limestone—appear to retain their bulk.

MATINAL LIMESTONE (TRENTON L. OF NEW YORK).

No traces of this formation have been met with in either of the great limestone basins S. of the Kittatinny Valley. Within that long limestone belt it appears and disappears, at intervals, from the Delaware River to Maryland, though probably it is absent through more than two-thirds of this distance.

Delaware River.—The formation has been measured only on Martin's Creek, near the road leading from Easton to the Delaware Water-Gap. There it is well exposed, and exhibits its characteristic composition and fossils. Its thickness is about . . . . 350 feet.

Kishicoquillas Valley.—The next outcrop of the formation admitting clear measurement is Kishicoquillas Valley, about half-way across the Mountain Chain. Here, under its usual type of alternating thin layers of smooth dark-blue limestone and blue shale, and with its usual fossils, it has a thickness of . . 550 „

Nippenose Valley.—Advancing to the furthest north-western outcrop, the Matinal limestone appears throughout nearly the whole length of the Great Nittany Anticlinal, where the elevation is sufficient to bring it to the day. In Nippenose Valley, with numerous characteristic fossils, the rock graduates at its upper limit into the Matinal black slate. It measures . . . . 300 „

Nittany Valley.—In the neighbourhood of Bellefonte, a more south-western locality on the same belt, the Matinal limestone, in the condition of a bluish-grey, thin-bedded, but somewhat rubbly limestone, has a total thickness of . . . . 360 „

The lowest 60 feet is dark-blue, thin-bedded, and of the Trenton type.

Milliken's Cove.—Far to the S.W. the Matinal limestone is discernible in Milliken's Cove and the other limestone coves of Bedford County. It wears its usual type, and has the characteristic fossils, but is obviously of reduced thickness, when compared with its development N. of the Juniata.

MATINAL SLATE (UTICA SLATE).

Kittatinny Valley.—The first or most S.E. appearance of the Matinal black slate is in the Kittatinny Valley, where it occurs chiefly between the Delaware and Lehigh. On Martin's Creek, where it is finely exposed, it measures about . . . . 300 „

It grows thinner proceeding westward. Near Nazareth it is very carbonaceous, and at its outcrop is so soft as to be convertible into a pulverulent, dark pigment.

Kishicoquillas Valley.—This formation is well developed around the borders of nearly all the anticlinal limestone valleys of the Mountain Chain west of the Susquehanna. It is of full dimensions in Kishicoquillas Valley, where it is of its usual composition, but much intersected with cleavage. It measures, apparently, 400 „

It is recognisable by its Graptolites and other distinctive fossils.

Nippenose Valley.—In this anticlinal uplift the Matinal black slate abounds in its usual fossils, retains all its lithological characters, and exhibits a thickness of . . . . 300 „

Nittany Valley.—Near Bellefonte, and elsewhere along the N.W. border of the last great anticlinal, the Black slate, with its characteristic fossils, measures nearly . . . . 300 „

Milliken's Cove.—It occurs as far S. in the State as Milliken's Cove, with its usual fossils and in its full dimensions. The passage between its lower limit and the top of the underlying limestone being, as elsewhere, quite abrupt.

MATINAL SHALES (HUDSON RIVER SLATE).

As already stated, this, by far the largest formation of the Matinal series, is not susceptible of accurate measurement anywhere along the Kittatinny Valley, its main south-eastern outcrop. Reappearing all round the anticlinal limestone valleys between the Kittatinny and Alleghany Mountains, S.W. of the Susquehanna, it there displays itself in numerous good exposures.

Kishicoquillas Valley.—In Kishicoquillas Valley, the locality selected as being about half-way across the chain, the formation occurs under its usual Pennsylvanian type of a blue shale and slate, alternating with thin grey calcareous sandstones, and containing many distinctive fossils, especially towards its upper limit. It has a total thickness of about . . . . 1200 feet.

Nittany Valley.—Crossing north-westward to its last outcrop in the State, we find this rock ranging along the south-eastern base of the Bald Eagle Mountain, under an average thickness of about . . 700 „

An imperfect measurement in Nippenose Valley indicates its thickness there to be a little less, and in Bedford County it is perhaps somewhat greater.

Summary.—The whole formation presents a marked reduction in thickness as it spreads westward, or more properly north-westward ; but in crossing the Mountain Chain of Pennsylvania, it exhibits no approach to the highly calcareous type which it wears where it next re-emerges to the day in the distant anticlinal of Southern Ohio and Northern Kentucky.

LEVANT SERIES.

The Levant series, naturally divisible into three groups or distinct formations, is largely developed in the Appalachian Chain of Pennsylvania, from the Kittatinny Mountain, its most south-eastern outcrop, to the Bald Eagle Mountain, Dunning's Mountain, and Wills' Mountain, its most north-western. Each of the subdivisions undergoes a greater or less change of type in advancing across the Chain ; indeed, the middle member, or red shale and sandstone, does not show itself at all in the Kittatinny Mountain and other south-eastern outcrops; and the lower and upper formations, likewise thin towards the S.E., acquire their maximum development near the opposite side of the Mountain Zone. These Levant sandstones constitute, with the exception of the carboniferous sandstones enclosing the Broad Top Coal-field, all the mountain-ridges, and higher spurs, of the entire Chain west of the Susquehanna between the Kittatinny Valley and the valley at the base of the Alleghany Mountain.

Within this space a remarkable series of long, parallel, anticlinal undulations of the strata lift these rocks into the mountain-crests alluded to. In the part of the Chain occupied by Perry, Juniata, Mifflin, Union, and Centre counties, the chief anticlinal mountain outcrops of the Levant series are about nineteen in number ; while in the district south of the Upper Juniata, or that of Franklin, Huntingdon, Fulton, Bedford, and Blair, their outcrops amount to seven or eight.

With a view to avoid a too detailed tracing of the changing characters and dimensions of the three members of the Levant series, they will be described in this general sketch as they occur only in their south-eastern, middle, and north-western outcrops in the Chain.

LEVANT GREY SANDSTONE (ONEIDA CONGLOMERATE OF NEW YORK).

Kittatinny Mountain or South-Eastern Outcrop—Delaware Water-Gap.—At this locality the inferior group of the Levant series is very thick. It consists of two members. The lower is a grey sandstone and conglomerate, the pebbly beds most abundant near its base ; the upper strata are formed of finer-grained light-grey sandstone, with partings of light fissile slate. Whole thickness about . . . . 300 feet.

The second member is a softer sandstone, chiefly thin bedded, and in colour greenish-grey. Its thickness is about . . . . 400 „

Neither of these rocks contains any fossils.

Total thickness, . . . 700 „

Lehigh Water-Gap.—The next good exposure of the formation is at the pass of the river Lehigh. There the mass consists—

1st, Of very coarse quartzose conglomerate, ...	50 feet.
2d, An alternation of fine white sandstone and a nut coarse conglomerate, capped by a still coarser, .	75 „
3d, A coarse quartzose conglomerate, with beds of sandstone, ...	75 „
4th, Fine-grained white and grey sandstone, fine conglomerate, and layers of shale, . . .	200 „
Total thickness of the formation,	400 „

Susquehanna Gap.—The strata referable to this member of the Levant series at the Pass of the Susquehanna are, near the base, a very coarse heterogeneous red conglomerate, not more than 5 feet thick; and in contact with this, a compact white conglomeritic sandstone, in thickness not more than 40 feet. The sandstone exhibits oblique slips or faulty joints, and may originally have been somewhat thicker than it now measures. There is likewise a blank space between the southern limit of the conglomerate and the northern visible limit of the Matinal shale, amounting to between 40 and 50 feet more, and possibly a portion of this is occupied by beds of the Levant series. But making every allowance, we cannot attribute to this grey sandstone formation a greater total bulk than from 60 to . . . . 70 „

Comparing the three exhibitions of this stratum in the Kittatinny Mountain, it presents a remarkable reduction of size as it extends south-westward. But this feature is perfectly in accordance with what we know of the relations of the formation to the series upon which it reposes further to the N.E. in New York. There it rests unconformably upon the upturned edges of the Matinal strata; a fact which, taken in connection with its coarse, pebbly heterogeneous composition, shows that to have been the quarter of greatest disturbance of the sea-bed, at the time of the strewing in of its materials. It is easy, therefore, to understand how those materials should have been accumulated more abundantly than in the remoter localities to the S.W., where the agitations of the earth's crust were gentler.

Jack's Mountain, or *Middle Belt, Kishicoquillas Gap.*—Advancing now about half-way across the chain to the middle belt of outcrops, the first good exposure of the formation admitting of measurement is at the Kishicoquillas Gap in Jack's Mountain. The position of Montour's Ridge in Columbia County would make a comparison between the formation at that locality and the Kittatinny Mountain interesting; but unfortunately it is inaccessible to observation, the lowest rock visible in the anticlinal axis being an upper member of the Levant white sandstone group.

Contenting ourselves with the developments in Jack's Mountain, we have, at the Kishicoquillas Gap, the Levant grey sandstone, in the condition of a fine-grained, light-grey, massive sandstone, abounding in yellow ferruginous specks. It has here a total thickness of . . . . 300 „

Juniata Gap, or *Jack's Narrows.*—At this locality the stratum is a greenish white, hard, silicious sandstone, with a total thickness of . . . . 250 „

Comparing the two exposures in Jack's Mountain, we observe the same reduction of the formation south-westward that we have previously noticed in the Kittatinny Mountain; a further confirmation of the view adopted, that the materials of this deposit were swept in from the N.E. or E., and not from the S.E., as was the case with some of the other Appalachian rocks. The formation displays, however, an obvious augmentation of thickness, when we contrast it in this middle belt with its diminutive bulk in the Kittatinny Mountain opposite.

Bald Eagle and Wills' Mountains, or *North-Western Outcrop, Bellefonte Gap.*—There is no sufficiently complete exposure of the Levant grey sandstone admitting of measurement, in the Muncy and Bald Eagle Mountain, until we advance as far to the S.W. as the Gap near Bellefonte. At this spot there are two groups of strata, the lower, a hard grey sandstone without pebbles, but full of the characteristic yellow specks, its thickness being 170 feet; and an upper, composed of greenish-grey slightly micaceous saudstone, with the ochreous specks, and divided by thin layers of a fissile greenish slate, under a thickness of 380 feet. Possibly the upper member should belong to the Levant red sandstone, or middle formation of the series; but its characters place it rather in the grey sandstone. Thus constituted, the formation measures . . . 550 „

Canoe Mountain Gap, Juniata River.—This locality is not quite on the line of the most north-western outcrop, but is near enough for general comparison. All the Levant formations are well exposed here. The grey sandstone wears its usual character of a grey-greenish and pinkish hard silicious sandstone, in massive beds. Its thickness amounts to nearly . . . . 500 „

The next outcrop eastward exhibits the formation at Water Street in Tussey Mountain, under a thickness of . . . . 450 feet.

Wills' Mountain, Milliken's Cove.—The last locality at which this rock is to be seen, to the S.W. along its north-western outcrop, is in the main gap entering Milliken's Cove of Wills' Mountain. There the rock, as visible, measures only about . . . . 100 „

Looking at the very notable difference in its thickness here, when compared with that on the Juniata, one is disposed to suspect an obscuration of the lower portion of the mass, from a possible fault along the western edge of Milliken's Cove ; a conjecture suggested by the vertical and shattered condition of the strata in Buffalo Ridge, the western barrier of the Cove. Should this not be the case, the formation has undergone an unusually sudden diminution in its bulk. We are nevertheless warranted in looking for some abatement of thickness towards this south-western quarter.

General Survey of the Formation.—It will be seen, upon scanning the facts here recorded of the Levant Grey Sandstone, that while it displays a marked declension of size from the Delaware to the country west of the Susquehanna, or in the direction of its first outcrop, and exhibits a corresponding, but less notable declension in the same south-west direction along its middle and north-western belts, it presents, in a transverse or north-west direction across the Chain, an almost equally rapid augmentation of its bulk. We may look upon the successive anticlinal and synclinal outcrops and undulations of the stratum as but portions of a deposit originally continuous, from some unknown limit south-east of the Kittatinny Mountain to an undefined north-western or western boundary, where the oceanic waters of the Levant period ceased to deposit their materials. Within the mountain-range, where alone this broad sheet of matter has been lifted to view, or where lifted, preserved in the general denudation, we discover a progressive enlargement of its mass within the Chain, both eastward and north-westward, indicating some north-easterly quarter as the direction of its maximum average expansion. There can be little doubt that, after the tremendous crust-movement which partially upheaved and drained the bed of the Matinal ocean, the trend of the newly-established shore of the contracted waters was N.E. and S.W., and the sea-shore itself at no great distance S.E. of the Shawangunk and Kittatinny Mountain. And it is a fair deduction from all the assembled facts, that the first strong currents at least of the Levant period, or that strewing the grey sandstone, came from the N.E., and spent themselves south-westward and westward. We have evidence in the stratification of Virginia that it carried its materials far south of the Potomac ; but how far in a westerly direction it swept them out into the mid-sea, which existed where we have now the great coal-basin of Western Pennsylvania and Ohio, it is beyond the power of man to divine. The wide anticlinal uplift of Ohio, Middle Kentucky, and Tennessee, brings the Matinal shales conspicuously to the surface, but shows them immediately overlaid by the Scalent rocks, and in some places by yet higher formations, enabling us to perceive that there was not a vestige of the sediments of the Levant period deposited so far towards the W. And this conclusion is confirmed when we pass still further across the floor of the ancient Palæozoic sea, and discover a similar total absence of the Levant materials at the upper limit of the Matinal shales in Wisconsin and Missouri.

LEVANT RED SANDSTONE (MEDINA RED SHALE OF NEW YORK).

It has been already intimated that the Levant Red Sandstone has no existence, so far to the S.E. as the Kittatinny Mountain. It first shows itself in the south-eastern part of the Mountain Chain to the west of the Susquehanna, in Perry and Franklin counties. The formation becomes for the first time conspicuous in the Tuscarora Mountain, being cut into on the anticlinal axis, at the pass called Run Gap. It is feebly developed in the ridges enclosing Path Valley. In the long complex anticlinal belt, or group of anticlinal mountains, the Shade, Blue, and Black Log mountains, this formation is still more expanded, forming there, wherever the denuding waters have cut the series deep enough, a distinct bench or terrace below the level of the higher crest. But no good exposure offers itself in this zone for measuring the thickness. We must, therefore, select the nearly central outcrop, or that of Jack's Mountain, for the first distinct development, admitting of satisfactory observation of the type and thickness of the stratum. It has been already intimated that this rock does not show itself in Montour's Ridge, the elevation and erosion of the strata there not having proceeded quite far enough.

Jack's Mountain, Kishicoquillas Gap.—At this most north-eastern exhibition of the Levant Red Sandstone, it consists of three members, the lowest a pale, red sandstone, imbedding pebbles of quartz, Matinal slate, and other older Appalachian rocks, 400 feet in thickness, surmounted by a coarse, friable red sandstone, sprinkled in some layers with small pebbles, and full of large ferruginous spots, 100 feet thick; and this overlaid in turn by a dark-red, flaggy, and in part argillaceous sandstone, containing in some layers pebbles of red shale; thickness 500 feet. The total thickness of this well-characterised formation is thus, at this locality, about . . . . 1000 feet.

Juniata Gap, or *Jack's Narrows.*—Here the rock is a red argillaceous sandstone, speckled yellow with hydrated peroxide of iron, and alternating with red shale. The sandstone beds abound in oblique laminæ, or false bedding. Thickness . . . . 650 „

North-western Outcrop, Bald Eagle Mountain, Bellefonte.—The most north-eastern locality along its north-western outcrop, at which the Levant Red Sandstone has admitted of measurement, is the Bellefonte Gap. There it is a thin bedded grey and red argillaceous sandstone, alternating with a fourth part red, grey, and greenish shale. High in the mass are found stem-like vegetable forms resembling an irregular *Scolithus.* This appears to be the *Scolithus verticalis* of Hall, a fossil of the Medina Sandstone of New York. The thickness of the rock here is about . . . . 500 „

Canoe Mountain Gap, Juniata River.—At the gap of Canoe Mountain this rock is a reddish brown, rather argillaceous sandstone, with beds of grey sandstone, all alternating with much red shale. Here its thickness is expanded to . . . . 1050 „

In the next south-eastern outcrop of *Tussey Mountain,* at the gap called Water Street, the whole mass, possessing the same general composition, measures . . . . 700 „

Milliken's Cove.—At this locality, which is upon the same general line of outcrop, the rock holds its prevailing north-western characters, except that it includes a larger amount of grey sandstone than on the Juniata. Its thickness is . . . . 800 „

General Survey of the Formation.—Comparing the data afforded by the above records, we perceive that this formation, while it dilates rapidly in thickness as we meet it going northward, exhibits at the same time, at its successive outcrops, a fluctuation in its dimensions. The direction of its maximum increase would seem to be nearly westward on the parallel of the Juniata River; but we are not in possession of a sufficiently numerous and widely-dispersed series of measurements to deduce any general inferences respecting the direction of its more permanent development, or the quarter from whence its sediments have entered this portion of the ancient Appalachian Sea.

LEVANT WHITE SANDSTONE (PART OF MEDINA GROUP OF NEW YORK).

The upper formation of the Levant Series, a somewhat complex group of white sandstones and olive-coloured slates, ranges, as already indicated, with the lower or grey sandstone through the entire breadth of the Appalachian Chain, from the Kittatinny Mountain to the Bald Eagle and Wills' mountains. Of the three Levant formations, it is altogether the most fluctuating as respects its subdivisions or general type, though in regard to its thickness it is apparently the most constant. The fluctuations it undergoes result from the coming in and thinning out of some, or nearly all, of its sandstones and slates. Perhaps the most persistent of its members is a mottled red and white hard sandstone, in comparatively thin layers high in the formation, well characterised by impressions of the *Arthrophycus Harlani.* This appears to be the typical rock of the Medina Sandstone of New York.

Kittatinny Mountain, or *South-Eastern Outcrop—Delaware Water-Gap.*—Selecting the same localities as those previously chosen for exhibiting the other formations of the Levant Series, we shall commence with this at the Delaware Water-gap. It here consists of a light-grey and olive-grey compact sandstone, in some beds sparsely pebbly. This member, forming a prominent rib of the mountain, is about 200 feet thick. Overlying this are some alternating beds of sandstone and slate, but whether these are properly referable to this formation, or to the lower part of the overlying Surgent series, is somewhat uncertain, the outcrops being obscure.

Lehigh Water-Gap.—At the Lehigh Water-Gap there is a thick succession of alternating white sandstones and olive shales, the upper sandstones being mottled red and white, and containing the characteristic Marine vegetatiou. There is a deficiency of exposures in the lower part of the formation through more than 200 feet, though the fragments indicate both grey sandstone and the olive-coloured shales. There then succeeds a white and grey pebbly sandstone, 80 feet thick. Above this repose alternating greyish white sandstones and brownish sandy shales, about 100 feet thick, overlaid by white sandstone and brownish and green slates, vaguely marked by fucoids 50 feet thick, succeeded by sandy shales, brown, olive, and yellow, 30 feet thick. Capping these are olive and buff, green and brown shales, with grey and greenish flaggy sandstone, 300 feet thick. These bring us to the uppermost bed of the formation, which is a massive red and grey quartzose sandstone, intercalated with olive and yellowish shales, the whole group having a thickness of 100 feet.

The aggregate bulk of the formation is therefore about . . . . 760 feet.

Susquehanna Gap.—It is impossible, from the lack of clear exposures of the strata, to determine with precision the other different members or the total thickness of the Levant White Sandstone formation at the Susquehanna. It is sufficiently obvious, however, that it consists there, as elsewhere, of an alternation of white sandstones, with greenish and yellowish slates, and that it has reddish sandstones, with marine plants among its upper layers. Its total thickness may be estimated at from 300 to . . . . . . 400 „

This formation, so obviously below its average size in the south-western part of the Kittatinny Valley, augments steadily as we meet it rising in its successive anticlinals through Perry, Juniata, and Mifflin counties, in crossing north-westward. As only its uppermost members are visible in Montour's Ridge, at the Danville Narrows, it is impossible to estimate its bulk in the middle belt of the chain to the east of the Susquehanna; but westward of the river it has been measured at all the localities already given as exposing the other two lower Levant formations, except the Kishicoquillas Gap.

Jack's Mountain, South-East Flank—Juniata Gap, or *Jack's Narrows.*—At this interesting locality the Levant White Sandstone is composed, 1st, Of two principal massess, the inferior a white and greenish-grey silicious sandstone, generally massive and very compact, with scarcely a trace of organic remains, its thickness being 420 feet; and, 2d, Of a red sandstone, alternating with grey and pinkish sandstone, and green and red shale, only 30 feet thick. The uppermost, or thin member, has some of its sandstone layers covered with a network of the *Arthrophycus Harlani.* Total thickness of formation . . . . . 450 „

North-Western Outcrop—Bald Eagle Mountain — Bellefonte.—Here the Levant White Sandstone has its usual composition, and though not measurable with perfect precision, its thickness is evidently between 400 and 500 „

Canoe Mountain-Gap of the Juniata.—Here the formation is a rather homogeneous mass of white and grey fine-grained sandstone in ponderous beds. Its thickness, carefully measured, is . . . 550 „

At the Gap of Water Street, in Tussey Mountain, with a similar composition, the thickness of the mass is 500 „

At both localities the *Arthrophycus Harlani* abounds near the top of the formation.

Milliken's Cove.—In the Buffalo Ridge, the western barrier of this anticlinal valley, the Levant White Sandstone exists, well exposed under its prevailing north-western homogeneous type. Its thickness here is about . . . . 400 „

General Survey of the Formation.—At the Susquehanna, and also at the Delaware Water-Gap, the Levant White Sandstone is too vaguely defined in composition and limits to permit us to trace its changes in the Kittatinny Mountain. We are able, however, to recognise it, especially at the Lehigh Water-Gap, as possessing in this its south-eastern outcrop its most complex type. Contrasting the aspects of the rock here, and in the central belt, it manifestly becomes more arenaceous as it spreads north-westward, from a diminution of its shales, which at the Lehigh greatly preponderate over the sandstones, and from a positive and rapid augmentation of the latter. The upper part of the formation retains its mixed type of olive shales, and close-grained white sandstones, as far even as Jack's Mountain; for in the belt next to the S.E., or that of the Shade and Black Log ridges, the alternation of these is conspicuous. The Pennsylvania Canal is excavated in this alternating upper division of the formation through the Long Narrows of the Juniata. It is an interesting fact that this series is nearly constant in its thickness throughout its middle and north-western outcrops. It is to this uniformity of bulk, and to its equally remarkable permanency of composition and hardness, that we must ascribe the extraordinary evenness of height and width in the sandstone crests of all this portion of the mountain-chain.

While speaking of the Levant grey sandstone, it was shown that none of the formations of the Levant period reach westward to the anticlinal of Ohio and Kentucky; but casting a glance northward to the geology of the basin of Lake Ontario, we can discern the western limits of each of the three formations, under the names of the Oneida Conglomerate, Medina Shale, and Medina Sandstone, the Oneida Conglomerate extending no farther than the eastern end of Lake Ontario, the Medina Red Shale and its overlying sandstones running on across the Niagara River, and thence north-westward nearly to the Straits of Mackinac.

From these statements it is obvious that the Middle and Upper formations, deposited in more tranquil waters, were much more widely diffused, both south-westward and north-westward, than the coarser, more heterogeneous grey sandstone beneath them; the red shale, the finest sediment of all, spreading the farthest distance.

SURGENT SERIES.

The Surgent group of formations, like the Levant series, with which it is intimately connected, is in great force throughout the Appalachian Chain of the State, from the north-west flank of the Kittatinny Mountain to the similar slope of the last Main Ridge east of the foot of the Alleghany Mountain. It consists of seven formations or sub-groups of strata, and each of these varies in its type and thickness within the space described, independently of the others. Some of them, indeed, are altogether wanting in the Kittatinny Mountain, and other south-eastern outcrops. As these Surgent rocks adjoin those of the Levant series immediately beneath them, they observe almost precisely the same topographical distribution; the chief difference being, that whereas the Levant usually form the crests of the synclinal ridges, these constitute one flank and base of the monoclinal ones, and both slopes of the anticlinal. They likewise stretch away in tapering belts, from the terminal spurs of the mountains, some distance forward into the plains.

SURGENT LOWER SLATE (BASE OF CLINTON GROUP OF NEW YORK).

SOUTH-EAST BELT, or Kittatinny Mountain and Perry County.

At the *Delaware Water-Gap* this formation is too obscurely visible to admit of measurement or description.

At the *Lehigh Water-Gap* it may be distinctly recognised and measured, having a thickness of about 100 feet.

In *Perry County* it exhibits its usual type of a fissile, olive-coloured slate, becoming claret and liver-coloured by exposure. It measures from 150 to . . . . . 200 „

Middle Belt.

At *Mifflintown* the Surgent lower slate, olive-coloured and fissile as usual, measures . 150 „

At *Danville* it is a greenish slate, weathering yellow, and containing bands of a block iron ore. It measures apparently . . . . 700 „

At the south-east base of *Jack's Mountain, Jack's Narrows,* &c., this formation is not separable from the Surgent upper slate, owing to the absence of the iron sandstone, the two together consisting of, A, green slate, with a few thin calcareous layers; B, yellow and olive slate, with very little calcareous matter, but some thin, sandy beds; measures from 500 to . . 550 „

North-West Belt.—*Milton,* and north-west of the Muncy or *Bald Eagle Mountain.*

Along this outcrop all the three members of the Surgent slate group are present; but the exact position and thickness of the Surgent iron sandstone are not easily ascertainable. The whole group measures . . . . 700 „

Survey of the Formation.—This member of the series appears not to fluctuate much in the north-east and south-west direction, but it undergoes a marked increase of thickness towards the N.W. Beyond the Appalachians, however, it is again, upon its reappearance at the surface in New York, much thinner, being seldom more than 50 feet.

SURGENT IRON SANDSTONE.

South-East Belt.

At the *Delaware Water-Gap* this rock has escaped notice, if indeed it exists.

At the *Lehigh Water-Gap* its thickness is . . . . . . 4 feet.

In *Perry County,* in the Kittatinny Mountain, it is . . . . . 80 „

It is thinner further N.W.

Middle Belt.

Near *Mifflintown* it is a ponderous red and brown ferruginous sandstone, with partings of slate. It contains trails or tracks of some animal. Its thickness is from 20 to . . . . 25 „

Near *Danville* it is an alternation of olive sandy slate, and brown heavy sandstone, containing the block iron ore. It measures . . . . . . 58 „

At Jack's Mountain it is absent.

On the *Potomac* it is 3 or . . . . 4 „

In *Wills' Creek Axis* it is . . . . 30 „

North-West Belt.—This rock is present in the north-west outcrop, but its thickness is unknown.

Survey of the Formation.—This rock, seldom more than 50 feet in thickness, appears to observe no law of regular development in any given direction, but, like many other of the Appalachian sandstones, fluctuates variously.

SURGENT UPPER SLATE.

South-East Belt.

At the *Delaware* this rock exists apparently in much force, but cannot be easily measured.

Near the *Lehigh Water-Gap* this slate passes so insensibly into the Surgent lower shale, that the two must be measured together. Their thickness amounts to about . . . 166 feet.

In *Perry County,* under the form of a dingy olive slate, it measures . . . 100 „

Middle Belt.

Near *Mifflintown* it is a green and claret-coloured slate. Its only fossils are faint fucoids. It measures from 200 to . . . . 250 „

Near *Danville* the formation is a green fissile slate. Thickness . . . . 50 „

In *Jack's Mountain* it is not separable from the Surgent lower slate, through the absence of the iron sandstone.

NORTH-WEST BELT.

Here, though separated from the Surgent lower slate, it is not independently measurable.

Survey of the Formation.—Like the Surgent lower slate, of which it is but a repetition, this stratum augments towards the N.W. through the mountain-chain.

On the *Potomac* the two slates measure together about 400 feet.

SURGENT LOWER SHALE.

SOUTH-EAST BELT.

It is doubtful if the lower and upper shales exist at the *Delaware Water-Gap;* their fossiliferous iron ores have never been discovered.

Near the *Lehigh Water-Gap* the lower shale, though present, is so united with the upper slate as not to admit of separate measurement.

In *Perry County* this formation is imperfectly developed; the calcareous fossiliferous layers are but little seen, even at Millerstown. The fossiliferous ore is barely recognisable. The whole measures, probably, ... 100 feet.

MIDDLE BELT.

Near *Mifflintown* it is a liver-coloured calcareous slate, imbedding thin layers of sandy fossiliferous limestone. Thickness uncertain.

Near *Danville* it is composed of green fissile shale, fossiliferous limestone, and fossiliferous iron ore. Total thickness, ... 60 feet.

In *Jack's Mountain* it is an olive and claret-coloured fossiliferous shale, with occasional thin layers of calcareous and argillaceous sandstone. It measures 200 to . . . 250 „

NORTH-WEST BELT.

In the *north-west outcrop* this formation is a greenish shale, with sandy calcareous layers—thickness 110 „

Survey of the Formation.—It would seem that this stratum first enlarges somewhat in spreading towards the N.W. across the mountains, and then contracts again to about its original thickness.

SURGENT ORE SANDSTONE.

SOUTH-EAST BELT.

At the *Lehigh Water-Gap* this formation is easily recognised. It measures . . 110 feet.

In *Perry County* it is a close, hard, white sandstone—thickness, . . . 15 „

In the south-east part of the county the iron ore underlies, in the north-west it overlies, and in some places it lies both below and above, the ore sandstone.

MIDDLE BELT.

Near *Mifflintown* the ore sandstone measures 20 to . . . . . . 25 „

Near *Danville* it is a tough calcareous sandstone—thickness, ... 8 „

In *Jack's Mountain* the ore sandstone measures . . . . . . 25 „

NORTH-WEST BELT.—Here this formation is absent.

Survey of the Formation.—Thickest towards the east; this rock, west of the Susquehanna, gradually thins away north-westward, but with fluctuations.

On the *Potomac* it is 30 feet.

SURGENT UPPER SHALE.

SOUTH-EAST BELT.

At the *Lehigh Water-Gap* it measures . . . . 120 feet.

In *Perry County* this formation is a calcareous olive shale; it weathers buff, and contains the fossiliferous ore. It measures in the S.E. 30 to 50 feet, in the N.W. 150, and has an average thickness of . 50 feet.

MIDDLE BELT.

Near *Mifflintown.*—Here it is composed of grey calcareous shale, with thin layers of fossilferous limestone—thickness 200 to . . . . 225 „

Near *Danville* it is a sandy, argillaceous, green fissile slate, with layers of fossiliferous limestone, and fossiliferous ore near the base—thickness, ... 160 „

In *Jack's Mountain* it is composed of altered olive calcareous shales, and thin beds of limestone. The lower beds of the latter are fossiliferous, while the upper beds are not so; it measures . 250 „

NORTH-WEST BELT.

The upper calcareous shales consist, ascending, of—

1. An alternation of slates and ferruginous limestones, with some fossiliferous iron ore, 60 feet.
2. Olive and buff shales, ... 65 „
3. Limestone with Beyrichia, ... 65 „
4. Grey and greenish shale, full of fossils, ... 40 „

Total, . — 230 „

Survey of the Formation.—This Upper Calcareous Shale group appears to enlarge gradually towards the N.W. Both it and the Lower Shale are, however, much thinner at their distant outcrop in Clinton County, New York, than in Pennsylvania, both masses there being seldom more than 20 feet thick.

On the *Potomac* the two shales together measure about 340 feet.

SURGENT RED SHALE—MARL.

SOUTH-EAST BELT.

At the *Lehigh Water-Gap* this formation is abundantly developed. It has a thickness of about 975 feet.

In *Perry County*, at the Susquehanna Gap, it measures . . . . 400 „

MIDDLE BELT.

Near *Mifflintown*, where it contains the Clinton fucoid, or *Buthotrephis gracilis*, its thickness is . 340 „

Near *Danville* it is a uniform red shale, without fossils, and measures . . . 380 „

In *Jack's Mountain* the red shale exists in full development, but its thickness is undetermined.

It measures at Newton Hamilton, ... 250 „

And at Lewiston, about . . . . 160 „

On the *Potomac*, at the Capon Axis, it is about . . . . . 100 „

NORTH-WEST BELT.

Here the Surgent red shale maintains its usual constant characters. It is without fossils. Its thickness is . . . . 350 „

In *Blair* and *Bedford* it is much thinner, and at the *Potomac*, near Cumberland, it is wanting entirely.

General Survey of the Formation.—It would seem, from the above local measurements, that the Surgent red marl or shale steadily thins towards the south-west, and at the same time towards the north-west, but much more gradually. In the latter direction it appears in New York, near Lake Ontario, but reduced to a very slender deposit.

SCALENT SERIES.

This series, the representative, in a general way, of the Onondaga-Salt and Niagara groups of New York, consisting, in Pennsylvania, of three subdivisions or formations, is in some districts of the Appalachian Zone in very great force. Its usual topographical position is in the valleys at the feet of the high monoclinal and anticlinal ridges of the Levant sandstones, and on the adjacent sides of the neighbouring limestone ridges. The Niagara limestone, so important a formation in New York and the North-Western States, is absent from the series in Pennsylvania; but the Water-lime exists, and is very persistent throughout the Chain.

SCALENT VARIEGATED MARLS.

South-East Belt.		
At the *Kittatinny Mountain* it is not seen.		
Near the *Tuscarora Mountain*, where the stratum first appears in force, its thickness is about	100	feet.
Middle Belt.		
Near *Newton Hamilton*, where it consists of an alternation of red, bluish, and greenish shales, and thin layers of argillaceous limestone, it measures	285	„
On the *Potomac* at the *Capon Axis*, it is about	300	„
At *Mifflintown* it exceeds	440	„
At *Lewistown* about	450	„
North-West Belt.		
Near *Muncytown* this stratum is an alternation of red and green marl. It is only	20	„

Survey of the Formation.—This deposit exhibits a rather remarkable increase of thickness from the S.E. to the Middle Belt of the Appalachian Zone, and an equally remarkable decrease thence north-westward.

SCALENT GREY MARLS.

South-East Belt.		
At base of *Kittatinny Mountain* very feebly developed.		
Near *Tuscarora Mountain* it is a mass of grey, greenish, and bluish calcareous shales, in thickness about	600	feet.
Middle Belt.		
Near *Mifflintown*, it measures about	600	„
Near *Lewistown*, about	500	„
Near *Newton Hamilton*, consisting, in the lower part, of green and blue calcareous shales; in the middle, of the same, with flaggy limestone; and in the upper, of flaggy limestone, alternating with grey, blue, and olive calcareous marls. It measures	945	„
On the *Potomac* it is about	350	„
North-West Belt.		
Near *Milton* this formation consists of blue shales and thin layers of limestone, with thicker beds of blue fissile slate, underlaid by a thick succession of greenish and bluish marls, alternating with flaggy, argillaceous limestones. It contains few or no fossils. Its thickness is	1200	„
From *Muncy* south-westward, the formation grows gradually thinner and less diversified.		

Survey of the Formation.—West of the Susquehanna the Surgent grey marls seem to enlarge in bulk steadily towards the N., and more slowly towards the N.W., or they gradually decline south-westward.

SCALENT LIMESTONE.

South-East Belt.		
At the *Kittatinny Mountain* this rock is absent altogether.		
In the centre of *Perry County* its average thickness is	50	feet.
At the *Tuscarora Mountain* it is	200	„
Middle Belt.		
At *Mifflintown* it exposes, perhaps, more than	30	„
At *Newton Hamilton*, where it is a flaggy blue limestone, supporting 25 feet of chert, it measures	85	„
At *Lewistown* it is thicker.		
On the *Potomac* the thickness is about	350	„
North-West Belt.		
Near *Milton*, this rock, a thin-bedded blue limestone, with *Cytherina alta* and other fossils, has a thickness of	100	„
Between *Muncy* and *Jersey Shore* it is from 40 to	60	„

At *Frankstown*, where it is a blue flaggy limestone, imbedding chert between its upper layers, it measures more than . . . . 215 feet.

Survey of the Formation.—With considerable fluctuation this limestone appears to augment gradually south-westward, for in Blair and Bedford it is frequently thicker than 200 feet, and we have seen that it is still thicker on the Potomac.

PRE-MERIDIAN SERIES.

This remarkably persistent calcareous group of shaly and massive Limestones, with more or less Chert, is almost everywhere present west of the Susquehanna, where the undulations of the strata lift the middle Palæozoic rocks to the surface. Its orographic position is usually near the crests of the monoclinal ridges which next adjoin the mountains of the Levant sandstones, the very crests themselves carrying the overlying Meridian sandstone. Its distribution and changes of type will appear from the following details :—

PRE-MERIDIAN LIMESTONE.

South-East Belt.

Along the *Kittatinny Mountain* the formation is in some places quite thick; in others very attenuated, or gone altogether.

At *Broadheads Creek*, near the Delaware Water-Gap, it is a dull, blue, hard, and massive limestone, imbedding chert in its upper part. It abounds in corals. Thickness, . . 105 feet.

At the *Susquehanna Gap* there appears to be no trace of it.

At *Millerstown* it measures . . . . 100 „

At the *Tuscarora Axis*, the limestone is . . . . 140 „

The overlying chert, ... 25 „

It occurs here in two divisions, both fossiliferous—

A lower massive one, ... 60 „

An upper thin-bedded one, ... 80 „

In *Fulton County*, its average thickness is about . . . . . 250 „

Middle Belt.

Along this line the formation expands south-westward, but with fluctuations.

In *Montour's Ridge* it is . . . . 60 „

Between *Lewistown* and *Newton Hamilton*, where it is a blue massive encrinal and coralline limestone, it is . . . . 107 „

At the *Potomac*, above the mouth of the Capon, it is . . . . . . 24 „

The Pre-meridian chert varies from nothing to 30 feet, or more, being in Montour's Ridge thin and absent; west of Adamsburg, 30 feet; at Newton Hamilton, 0; and on the Potomac, 20 to 30 feet.

North-West Belt.

Near *Muncy* this rock is in its lower part a massive encrinal limestone, containing corals and other fossils, and is from 140 to . . . . 150 „

On the Juniata at *Frankstown* it is a massive blue and knotty limestone, with a bed of shale in the middle: its thickness is . . . . 135 „

Survey of the Formation.—With many fluctuations of thickness, but great general constancy of type, this rock rather augments in mass as we approach the Potomac. North-westward it is not thick, ranging from 20 to 50 feet in the valley N.W. of the Bald Eagle Mountain.

At its outcrop in the Helderberg Mountain, in New York, its thickness varies from 100 to 140 feet. South-westward along the Appalachian Chain this rock maintains its full bulk of 200 or 250 feet.

It seems not to spread to the western outcrops of the Appalachian strata in Middle Kentucky, Ohio, or beyond Western New York.

MERIDIAN SERIES.

This coarse and fossiliferous sandstone, with its frequently attendant shales, is one of the most constant of all the Palæozoic strata in Pennsylvania. It is rarely altogether absent; for even where, from its feeble cohesion and comparative thinness, it exposes no conspicuous outcrop, we may usually detect its presence at the places appropriate to it in a yellow sand derived from its disintegration. When in force, it usually occupies the crest of the narrow, sharp, stony ridges which next adjoin the high sandstone mountains of the Levant series.

MERIDIAN SLATE.

South-East Belt.

At the *Tuscarora Axis*, on the Susquehanna, this rock is chiefly the dusky, calcareous, sandy shale, and its thickness is . . . . 80 feet.

In the middle of *Perry County* it is about . . . . 40 „

At the base of the *Kittatinny Mountain* it is . . . . . . wanting.

From the Delaware to the Susquehanna, along the base of the Kittatinny Mountain, it fluctuates from 0 to . . . . 100 feet.

Middle Belt.

In this zone these sandy slates and shales, though variable, are thickest towards the N.E. Thus—

Near *Danville*, they are . . . . 30 „

Near *Newton Hamilton*, as friable sandy shales, from 40 to . . . . . 50 „

On the *Potomac* they are . . . . wanting.

North-West Belt.

In *Whitedeer Valley* these dusky shales, passing upward into argillaceous sandstone, measure about 70 feet.

Near *Muncy* the type is that of a dusky shale, weathering buff, the upper beds sandy and cherty, the thickness . . . . 60 „

Between *Muncy* and *Lockhaven*, ... 50 „

At *Frankstown*, on the Juniata, the formation embraces two divisions—

1. Dark ash and black slate, without fossils, ... 80 feet.
2. Dark grey, sandy, calcareous shale, with fossils, ... 90 „

—— 170 „

Survey of the Formation.—This interesting formation expands very slowly northward rather than north-westward. It does not appear to exist in New York, nor in any of the Western States, but it seems to run on south-westward into Virginia.

MERIDIAN SANDSTONE.

South-East Belt.

This formation, conspicuous and easily traceable wherever it possesses even a moderate thickness, is occasionally discernible N.W. of the Kittatinny Mountain, as near the Lehigh Water-Gap, in the crest of the first stony ridge.

At the *Lehigh*, where it is a pebbly sandstone, its thickness is 80 or . . . 90 feet.

At the *Susquehanna* it is . . . . wanting.

In *Perry County*, where it is frequently a pea-conglomerate, it is nowhere more than . 20 feet.

Middle Belt.

Along this zone the formation augments in thickness south-westward, but unsteadily.

In *Montour's Ridge* it is in some places hardly visible; in others it is . . . 35 feet.

From the *Susquehanna* to *Lewistown* it expands to . . . . . . 70 „

Near *Newton Hamilton*, where it is a massive, coarse calcareous sandstone, imbedding layers of chert in its lower portion, it measures . . . . . . 150 feet.

On the *Potomac* its dimensions are about . . . . . . 350 „

NORTH-WEST BELT.

In *Whitedeer Valley* it is . . . . very thin.

Traced along this belt, the sandstone increases in thickness south-westward from Muncy to Frankstown, and thence declines to the Potomac.

Near *Frankstown*, where it is a calcareous fossiliferous sandstone, internally bluish, externally yellow, it measures . . . . 125 feet.

Survey of the Formation.—As already stated, this formation fluctuates, but it is in the main thickest westward and south-westward. It does not range into Western New York, but stretches along the Appalachian Chain far through the State of Virginia. It is not seen in Eastern or Middle Tennessee, nor anywhere west of the Appalachian Coal-field.

POST-MERIDIAN SERIES.

The formations of this series nowhere appear in Pennsylvania, except in the valley north-west of the Kittatinny Mountain, between the Walpack Bend of the Delaware and the Lehigh River; it is unnecessary, therefore, to trace their distribution in this place.

CADENT SERIES.

The Cadent formations, some of which are among the most astonishingly persistent of all the Appalachian Palæozoic deposits, occur in superb development in many portions of the Mountain-chain of the State. Topographically considered, they occupy the sides of the long synclinal and monoclinal valleys south-west of the Susquehanna, and the more central parts of some of the anticlinal valleys or plains outside of the outer ridges confining the Anthracite Coal-fields. These three formations, the Lower and Upper Black Slate, and an interposed Olive Shale, undergo but few changes of type, except that of thickness; but this being a material element, its variations in regard to each must be noted separately.

CADENT LOWER BLACK SLATE.

SOUTH-EAST BELT.

Along the valley N.W of the Kittatinny Mountain this formation is, for the most part, very thin, or altogether wanting.

At the *Susquehanna Gap* its thickness is quite insignificant.

In *Perry County*, it consists, at the Half-Fall Mountain, of—

1. Buff and grey Calcareous Shale, imbedding a minute plant,	25 feet.	
2. Pale-green Argillaceous Limestone and Green Shale,	20 „	
3. Black fissile Carbonaceous Slate, full of the usual fossils,	180 „	
Total thickness,	——	225 feet.

MIDDLE BELT.

Along this zone the deposit is somewhat inconstant in its thickness, though very persistent in its composition, excepting as to its iron ore.

Near *Selinsgrove*, on the Susquehanna, it measures . . . . . . 665 „

It is there a black fissile pyritous slate with layers of impure limestone.

At *Lewistown* it is several hundred feet thick.

On the *Potomac*, near *Sideling Hill*, it is an ash-coloured and black slate, passing upward into black fissile slate and impure clayey limestone. Its thickness is . . . . 590 „

North-West Belt.

In the Whitedeer Valley this formation is a fissile black slate, with large lenticular cakes of blue limestone and septaria in its lower half. These become more continuous further S.W. Its fossils are few. The thickness here is from 600 to . . . . 800 feet.

Near *Frankstown* it is a black fissile slate, with cement layers near its base. Its thickness is more than . . . . 300 „

On the *Potomac* it measures upwards of . . . . 400 „

Survey of the Formation.—It undergoes a marked expansion northward in the Appalachians, and a much less rapid augmentation south-westward along the Chain, as far at least as the Potomac and interior of Virginia, beyond which it steadily diminishes, to disappear in Eastern Tennessee. It is probably wanting altogether in the Western States, the Black Slate of the west appearing to be the Cadent Upper Slate.

The thick layer of impure argillaceous limestone accompanies this slate near its base, in Fulton and other neighbouring counties.

CADENT SHALES.

South-east Belt.

This formation ranges parallel with the Kittatinny Mountain, from the Delaware River to Perry County, as a mass of grey and olive shales, growing gradually sandy until, between the Schuylkill and the interior of Perry, they become an argillaceous sandstone, with even some silicious conglomerate. This sandstone character, however, fades rapidly north-westward, and ceases between the Tuscarora and Shade mountains, the rock assuming its normal composition of a true shale or fine sandy mud.

Along the south-east side of *Perry* this rock is . . . . . 800 feet.

In the *Half-Fall Mountain* on the Juniata, where the formation is a hard fossiliferous sandstone, it measures between 600 and . . . . 700 „

Middle Belt.

On the *Potomac* the formation is at its maximum, or . . . . . 1100 „

North-West Belt.

In *Whitedeer Valley*, where the rock is an argillaceous and calcareous blue sandy shale and sandstone, with numerous fossils, its thickness is from 600 to . . . . 800 „

Between *Frankstown* and the foot of the Lock Mountain it is . . . . 400 „

From *Hollidaysburg*, south-westward, the formation grows very thin.

At *Cumberland*, on the Potomac, it is . . . . . . wanting.

Survey of the Formation.—This formation, the Hamilton Group of New York, increases in its average thickness to the Potomac, and ranges thence south-westward along the Appalachian Chain, until it expires near the James River in Virginia. In the Western States this middle deposit of the Cadent period appears to have no existence.

CADENT UPPER BLACK SLATE.

South-East Belt.

On the *Lehigh*, north of the Kittatinny Mountain, the Calcareous Upper Black Slate is seen under a thickness of from 220 to . . . . 250 feet.

In *Perry County* the rock is altogether . . . . . . wanting.

Middle Belt.

On the *Potomac* this rock measures . . . . . . 415 feet.

North-West Belt.

Throughout this belt the deposit is usually a bluish-black fissile slate, with minutely-divided particles of mica, and a small sagitate fossil.

In *Whitedeer Valley* it measures 200 to . . . . . . 300 „

In the *Muncy Hills*, and north-eastward, 250 to	300 feet.
Near *Frankstown*, it is from 300 to	350 „
On the *Potomac*, near Cumberland, it is not less than	700 „

Survey of the Formation.—This very widely-diffused deposit of ancient black Carbonaceous Mud appears to augment pretty steadily in a westward direction across the Chain. In Virginia it appears to attain its maximum near the James River, having a thickness on Dunlap's Creek of 850 feet. It thins away altogether in Eastern and Middle Tennessee. Westward along the northern outcrop of the great Appalachian Basin, it stretches through New York, Ohio, and Indiana, into Northern Illinois, where it comes gradually to a thin feather-edge. From the best authorities it reappears, however, far to the N.W., in British America.

VERGENT SERIES.

This series, consisting of two closely-related formations, a group of flaggy Sandstones and Shales, and a group of Fossiliferous Shales, occurs at every large outcrop of the middle Palæozoic strata within the State. The two formations observe somewhat opposite directions for their maximum development, and must therefore be traced separately. They occur, for the most part, ranging centrally along the synclinal and monoclinal valleys embraced between the Mountain Ridges, composed of the Levant sandstones on one or both sides.

VERGENT FLAGS.

South-East Belt.

These rocks may be recognised on the Lehigh under a somewhat more than usually argillaceous type. Some of the thin flaggy layers are imprinted with the trails of molluscs and other marine creatures. The thickness of the formation here has not been ascertained.

In *Perry County* this group is	wanting.

Middle Belt.

Near *Catawissa* the formation, with its characteristic fucoids or marine plants, appears under a thickness of	1000 feet.
Near *Huntingdon* it is a little thicker, being about	1700 „
On the *Potomac* it is again less developed, being about	1200 „

North-West Belt.

Along this line of outcrop, at the base of the Alleghany Mountain, the thickness of the group, as well as its characters, are very constant.

At the *West Branch* of the Susquehanna it is about	1200 „
At *Hollidaysburg* it is a little thicker.	
At the *Potomac* it is	1400 or 1500 „

Along this line the mass consists of dark-grey flaggy sandstones, parted by thin layers of blue shale. Large marine plants, and *a Nucula*, are its chief fossils.

Fourth Belt.

In *Bradford* and *Tioga* counties the Vergent Flags are	1000 „
On the *Genesee River*, in New York, it measures about	1000 „

There the deposit consists of thin-bedded, fine-grained, silicious grey sandstones, intimately alternating with blue and greenish shales.

Survey of the Formation.—This formation appears to augment slowly towards the N., the W., and the S.W.

VERGENT SHALES.

SOUTH-EAST BELT.

On the *Lehigh*, the whole Vergent series, consisting chiefly of this group, measures about .	1750 feet.
In *Perry County* the Vergent shales consist of two members,—	
1st, A lower, composed of olive-grey and blue shales and grey sandstones, with a dark slate at the bottom: this is about	1700 „
2d, An upper, of brown shale and sandstone, alternating with grey shale and sandstone, .	700 „

MIDDLE BELT.

At *Catawissa* this deposit—an alternation of grey, red, and olive sandy shales, with grey and red argillaceous sandstones—has a thickness of	3050 „
Near *Huntingdon* this formation, not very fossiliferous in type, has a thickness of . .	3200 „

NORTH-WEST BELT.

On the Portage Railroad, and extensively along the base of the Alleghany Mountain, the average thickness of the formation is not far from	2200 „
On the *Potomac*, a few miles east of Cumberland, its thickness is between 2100 and . .	2400 „

FOURTH BELT.

Between *Mahoopeny* and Tioga Point it is apparently	2500 „

FIFTH BELT.

On the *Genesee River*, New York, it is	1500 „

Survey of the Formation.—This very thick formation, remarkable for its general uniformity of composition, appears from the above statements to have its maximum development in the region of the Juniata, or half-way across the Appalachian Chain. Though it gradually thins towards the W., it is a rock of wide extension in that direction, spreading into Ohio, Kentucky, and Middle Tennessee, and along the Appalachian Chain. It stretches in full force through Virginia, and reaches East Tennessee, and probably Alabama.

PONENT SERIES.

The Ponent strata of the Appalachian Chain constitute a thick and remarkably uniform deposit, which does not admit of subdivision, either by its fossils or its mineral composition. Unlike some of the great groups, which gradually assume new phases, by the loss or the acquisition of subordinate members, or by mutations in the members they retain, this series undergoes almost no important modification but that of thickness. Adjoining, as it does, the overlying Vespertine sandstone, which, from its bulk and superior hardness, almost invariably occurs in the shape of a high ridge, this Ponent group occupies generally the slope and foot of the Vespertine mountains. Thus it forms the south-eastern flank and base of the main Alleghany Mountain throughout its entire course across the State. And it everywhere falls into a like position in the exterior or Vespertine Mountain ridges which encircle the whole anthracite Coal region. The formation exhibits a very interesting gradation in its dimensions as it spreads through the State, which the following details will show.

SOUTH-EASTERN BELT.

It has its thickest development at its first or south-eastern outcrop, or in the valley N.W. of the Kittatinny Mountain.

At the *Lehigh River* it measures	5000 feet.
At the *Susquehanna* it is about	6000 „

MIDDLE BELT.

Throughout this belt the character of the deposit—which may be accepted as a fair type of the formation generally—is that of a red sandstone and red shale, containing, in their superior portion, grey and buff sandstones, alternating with grey and yellow shales, all surmounted by a conglomeritic rock, of a fine-grained red sandstone paste, imbedding pebbles of white quartz. No good exposures for measuring the Ponent rocks occur between Catawissa and the Potomac.

At *Catawissa* the formation measures	4172 feet.
On the *Potomac*, in Sideling Hill, its thickness is about	4500 „
NORTH-WEST BELT.	
Its average thickness along the Alleghany Mountain may be assumed at about . .	2000 „
Around the *Wyoming Basin* it is approximately	2500 „
Near *Tunkhannock*, where it preserves its middle type, being free from very coarse grits, and consisting of fine and argillaceous sandstones, with an increase of red and green shales, and with some calcareous layers, it measures about	1500 „
On the *Loyal Sock Creek* its thickness is nearly	1000 „
FOURTH BELT.	
Near *Ralston* it is between 550 and	600 „
In the *Armenia Mountain*, on the Williamsport and Elmira Railroad, it is . . .	400 „
On *Towanda Creek*, above Canton Corner, an approximate measurement shows it to be nearly	400 „
FIFTH BELT.	
In the *Tioga Valley*, near the State line, according to the Geological Survey of New York, its thickness is	400 „
Near *Ellisburg*, between Coudersport and Wellsville, New York, it measures only . .	90 „
It consists in this district of greenish, sandy shale, red marly shale, and very thinly bedded micaceous and shaly sandstone.	
Near *Smethport* its probable thickness is somewhere near	170 „
In this district the deposit consists of red marly shale, and a bright green ferruginous sandy shale and argillaceous sandstone, forming a red soil. A curious dark, rough, pebbly rock occurs in the red shale.	
Near *Olean*, N. Y.—In the valley of the Alleghany River, south of Olean, the Ponent mass—chiefly a red shale—has an apparent thickness of	50 „
At *Warren*.—No trace of the Ponent formation is visible around Warren, nor any red shales referable to the series. Here the Alleghany River flows outside, or west of its western margin.	

Survey of the Formation.—From the foregoing statements it is obvious that this great homogeneous deposit thins away steadily and rapidly towards the N.W., from its maximum development at its south-eastern outcrop, near the Susquehanna River. This abatement of the mass is regular and not fluctuating, a fact which confirms the inferences to be deduced from its uniformity of composition; namely, that it was deposited all from one quarter, and during one long uninterrupted condition of the physical geography. From Pennsylvania the formation may be traced south-westward along the Appalachian Chain, with a gradual declension of size, until it finally thins out in eastern Tennessee. Dipping westward from the Appalachian Chain under the first great bituminous coal-field, it nowhere reappears at its western margin, but evidently ceases somewhere in the interval; nor does the formation, nor any equivalent of it, reappear anywhere in the Western States.

VESPERTINE SERIES.

The Vespertine group of strata, the first of the carboniferous formations of the Appalachians, has a very wide distribution in Pennsylvania, encircling with a sort of outer girdle all the coalfields, both the anthracitic and the bituminous ones, of the State. It undergoes gradual but important changes of type, growing thinner and assuming a finer and finer texture in its materials as it spreads westward. Its orographic position is in the mountain-ridges and external escarpments of the table-lands which enclose or support the coal-fields ; but, except in the north-western district of the State, it does not immediately adjoin the conglomerates and sandstones of the coal-measures, but is separated from them by a greater or less thickness of the soft, umbral rocks, which fill either an intervening valley or an intermediate space on the coal-bearing table-lands.

South-East Belt.

This great formation is thickest and most varied in its composition along its south-eastern outcrops, or where it surrounds the first anthracite coal-basin.

At *Mauch Chunk*, on the Lehigh, its thickness is . . . . . 1300 feet.

Near *Pottsville* the mass is about . . . . 1800 „

In the *Second Mountain*, on the Susquehanna, and in the *Fourth*, or *Peter's Mountain*, opposite *Duncannon*, it measures nearly . . . . 2000 „

Throughout this belt it consists largely of coarse grey sandstones and silicious conglomerates, with grey shales imbedding coal plants.

Middle Belt.

In the *Nescopeck Mountain*, north of the eastern Middle Coal-basins, the formation measures . 1100 „

At *Catawissa*, in the same line of outcrop, it is . . . . . 1044 „

Wyoming Basin.

Surrounding the northern or Wyoming Coal-field, the Vespertine series consists of a succession of grey sandstones, imbedding some pebbly layers and some beds of shale. It has everywhere a thickness of several hundred feet.

At *Cobb's Gap*, where it is made up chiefly of greenish-grey sandstones, it measures . . 310 „

At *Solomon's Gap*, where the greenish-grey sandstone is more argillaceous, and subdivided by more numerous and thicker layers of shale, and where the whole terminates upward in a stratum of coarse pebbly and micaceous sandstones, the entire mass possesses a thickness of about 560 „

At *Hertzog's Gap*, north of Kingston, the Vespertine series consists chiefly of olive and reddish sandstones and shales, with occasional layers of a coarse grey sandstone; the uppermost 80 or 100 feet include a mass of thick-bedded grey sandstones, passing towards the centre into a coarse conglomerate. The entire series measures here nearly . . . 600 „

North-West Belt.

In the *Alleghany Mountain*, on the *Loyal Sock*, its thickness is . . . . 900 „

East of the *North Branch* it is much thinner.

In this North-west Belt, and along the north side of the State, it is a somewhat argillaceous, micaceous flaggy sandstone.

Near *Wellsborough* the Vespertine deposit amounts to . . . . . 700 „

Fourth Belt.

At the *Conemaugh Gap*, S.E. base of *Laurel Hill*, the Vespertine formation is a grey sandstone with beds of shale, terminating upwards in a grey calcareous sandstone ; its thickness is 400 to 500 „

On the *Conemaugh Gap*, at the western slope of *Chestnut Ridge*, the rock is a grey argillaceous and micaceous sandstone, with a few beds of dark shale. Its thickness is . . . 349 „

Near *Astonville* this formation is a greenish, flaggy sandstone, with beds of grey sandstone and blue slate. Its thickness is . . . . 475 „

At the *Hill at Cartersville*, 1½ miles above Ralston, only the top of the Vespertine is seen.

At *Blossburg* the Vespertine sandstone consists of greenish and grey argillaceous sandstones, with a thin calcareous concretionary bed about 30 feet from the bottom. The whole formation possesses a thickness of . . . . 150 „

Fifth Belt.

In the vicinity of *Coudersport*, retaining its prevailing north-western type of greenish and grey sandstone, it seems to have a thickness of about . . . . . 300 „

It is very probable that a portion of this, perhaps the upper half, is to be ranked as umbral. An absence of fossils and a close assimilation in the types of the two series, render it difficult to define their common boundary.

Olean.—In the hills, three miles and more S. of Olean, the Vespertine Series, consisting of evenly-bedded greenish-grey sandstone, with partings of olive shale, measures about . . 100 feet.

It contains a *Scolithus,* or vertical worm-like form.

Warren.—Around this locality the group of rocks reposing directly upon the easily recognisable Vergent series, and overlaid by the Seral White Sandstone, and therefore referable to the Vespertine series, cousists of four members: the lowest is a group of thin-bedded sandstone and olive-grey shale, the sandstone containing a perpendicular, bifurcating stem-like fossil, and also a true *Scolithus.* This member is . . . . . . thin.

The second is a massive quartzose conglomerate, of smooth ovoid pebbles, about . . 10 feet.

The third member is a thick mass of olive-grey shale and thin-bedded sandstone, probably the Tionesta Coal-measures, though of the aspect of the Vespertine. It is about . . 175 „

The fourth, or uppermost, is a fossiliferous grey sandstone. Its thickness is 10 to . . 15 „

The Vespertine conglomerate caps the hills north-west of the Alleghany River. It is often mistaken for the Seral conglomerate and sandstone of the Coal-measures.

Survey of the Formation.—It is apparent from the measurements here given, that the direction of the maximum rate of diminution of this deposit is nearly due west.

UMBRAL SERIES.

The Umbral Series contains, in Pennsylvania, but one formation—the Umbral Red Shale. Though widely distributed, this is not coextensive with all the coal-fields, but thins out, as we shall see, under the bituminous coal region. Its prevailing character, which is that of a dark-brownish red shale and red sandstone, it steadily maintains throughout its range, except in Cambria and Somerset counties, where some greenish and blue calcareous shales or marls, and fossiliferous limestone, intrude themselves in the mass, to become, further towards the S.W. and W., an important independent formation. The Umbral Rocks very generally occupy, in the anthracite region, the valleys between the ridges of Vespertine sandstone, and those of the Seral conglomerate, or lowest coal-measures, and, in the bituminous coal region, the edges of the mountain table-lands between the same two formations. The following details will show a remarkable gradation in the thickness of this interesting deposit :—

South-East Belt.

Bordering the *Pottsville Coal-basin,* the thickness of the formation on the Lehigh at Mauch Chunk is about . . . . 3000 feet.

At *Mount Carbon,* on the Schuylkill, it measures . . . . . 2950 „

Near the *Susquehanna* it is rather less than this.

Middle Belt.

Wyoming Basin.—Around the Lackawanna Valley, or north-eastern division of the Wyoming Basin, the type which the Umbral formation wears is that of a mixed group of shales and fine sandstones—the inferior portion containing red shale; the middle, grey sandstones and buff slates; and the upper, a very close-grained calcareous sandstone, like hone. Near Scranton the red shale is extremely thin, and in some places entirely absent. From Scranton, south-westward, the relative proportion of this material augments, until, at Solomon's Gap, it greatly predominates in the mass, while the close sandstone of the middle and upper portions somewhat abates its thickness.

On the borders of the Lackawanna division of the basin, the average thickness of the whole formation is about 350 feet; but in the Western or Nanticoke district, the whole is two or three times as bulky.

At *Cobb's Gap* the entire series measures . . . . . . 440 feet.

At *Solomon's Gap* its thickness is . . . . 569 „

At *Hertzog's Gap, north of Kingston,* this Umbral formation consists of olive-coloured and red shales, alternating with red and grey sandstones. The whole possesses a thickness, below the egg and nut-conglomerate of the coal, of about . . . . 360 feet.

At *Nanticoke,* only the middle and upper portions are visible, the rest being concealed by the river. This visible part consists of soft calcareous red shale and sandstone, through a thickness of 260 feet, surmounted by thin-bedded grey sandstone, in alternation with olive-coloured shales, capped by the bone-like beds. Total thickness visible, about . . . 400 „

At *Broad Top Basin* the Umbral limestone is a rather silicious, slightly fœtid limestone, of a cloudy greenish white colour.

In *Trough Creek Valley* it measures 3 to . . . . 4 „

In *Ground Hog Valley* its thickness is . . . . 12 „

In *Brush Creek Valley* it is . . . . 20 „

THIRD BELT.

Near *Astonville* the Umbral series is composed largely, especially in its middle portion, of grey and greenish coarse sandstone, the thickness of which is . . . 350 feet.

This is underlaid by red and greenish shales and ferruginous sandstones, with Lepidodendron: thickness . . . . 87 „

And overlaid by a thin white conglomerate, ... 20 „

Surmounted by blue, and a blue and red shale, about . . . . 130 „

Total thickness, . . —— 587 „

In the *Hill* at *Cartersville,* 1½ miles from Ralston, the Umbral consists, in its lower part, of micaceous flaggy sandstone, in alternation with red and blue shales, in a thickness of about . . . . 300 „

Next a thin pebbly sandstone, and over this coarse white and greenish-grey sandstones, alternating with thinner beds of red and blue marly shale, nodular iron, as usual, occurring at the upper limit. Its thickness is about . . . 234 „

Total thickness, . . —— 534 „

At *Ralston Old Mines* the upper part only is seen. It is . . . 122 „

It consists of two soft marly shales, each between 40 and . . . 50 „

The lower red, the upper chiefly bluish and greenish, and between them argillaceous sandstones, including a layer of balls of iron ore, ... 24 „

The upper shale two or three feet of nodular carbonate of iron.

On *Fall Creek, Towanda Basin,* south side, the Umbral, as usual, in this region, is a triple group. Its lowest member is a soft red shale 18 to . . . . 20 „

Its middle, a mass of yellowish fine-grained argillaceous sandstone, imbedding near its centre about 4 feet of ferruginous shale, with massive mottled grey concretionary iron ore—the whole . . . . 134 „

Its upper bed is a ferruginous bluish shale, containing a little red shale, . . 14 „

Total thickness, . . —— 168 „

East of *Tioga River* the Umbral is very thin.

FOURTH BELT.

Blossburg.—Beneath this basin the Umbral series is a mixed group, composed of a large body of greenish grey sandstone throughout more than the lower half, and of red and green shales alternating with argillaceous sandstones in the upper part. The middle and upper portions contain several courses of nodular iron ore, consisting of carbonate of iron, with much extraneous matter, and in some layers partially oolitic. The thickness is . . . 238 „

At the *Conemaugh Gap*, south-east base—*Laurel Hill.*—The Umbral series consists of red shale, including, near its base, beds of light-blue sandy limestone, and near its superior limit grey and white argillaceous sandstone and iron ore. Its thickness is . . . . . . 370 feet.

On the *Conemaugh Gap*, at the Western Slope of *Chestnut Ridge*, the Umbral consists of the red marly shales, containing little grey sandstones in its upper half, centrally a thick bed of sandy limestone, and composed in its lower part of olive shale. Its total thickness is . 195 „

It would seem not to be overlaid by any conglomerate, but is succeeded immediately by coal-measures.

FIFTH BELT.

At *Coudersport* there is a greenish flaggy micaceous and argillaceous sandstone, including thin bands of red sandstone of similar composition. This rock, though possibly pertaining to the Vespertine series, is more probably the representative of the middle arenaceous member of the Umbral. It is overlaid by Umbral red shale, here very thin. The Umbral rocks appear to thin away altogether between Coudersport and Smethport.

Smethport.—The Umbral appears not to extend so far westward.

Survey of the Formation.—From the foregoing data, it would appear that this Middle Carboniferous deposit thins faster towards the north, but changes to a calcareous type farther towards the south-west.

SERAL SERIES.

The Seral conglomerate, the only portion of the Coal formation whose changes of type and distribution admit of a general survey, exhibits the following modifications :—

At *Mauch Chunk* its thickness is about . . . . . . 950 feet.

It is here composed of hard grey silicious conglomerate in ponderous beds, coarse grey sandstones, sandy clay-shales, and a few thin layers of fissile black coal, slate, and fire-clay.

At *Nesquehoning*, on Rhume Run, its thickness is . . . . . 792 „

At *Tamaqua* its thickness is about . . . . 803 „

Here it is an alternation of very coarse silicious conglomerate in massive beds, the pebbles of the size of an egg or orange down to that of a nut or pea; also of interposed coarse and fine grey sandstones, and here and there a sandy shale. There are also two or three thin imperfectly-developed beds of coal in it.

At *Pottsville* its thickness is about . . . . 1030 „

Here the rock contains a less amount of coarse conglomerate, a larger proportion of rough argillaceous sandstone, two or three bands of coarse shale, two or three beds of coal slate, and a very thin, imperfectly-formed layer of very slaty coal.

At *Lorberry Gap*, it is about . . . . 675 „

Here the group consists of five or six thick strata of coarse egg and nut-conglomerate, forming as many bold ribs in the Sharp Mountain, with interposed beds of coarse sandstone and sandy shale. It embraces three thin impure seams of coal, and possibly a fourth, with their coal slates.

At *Yellow Spring Gap—Dauphin*—its thickness is about . . . . 660 „

It is a compact sandstone in the lower and middle portions; an alternation of sandstone and conglomerate in the upper—the latter small in quantity.

At *Bear Gap, Wiconisco Basin*, it measures . . . . . 460 „

At this locality, and indeed in the outcrops of the base of the Coal-measures throughout the western part of the Wiconisco Basin, the group consists wholly of coal-measures, having lost entirely that preponderance of conglomerates and coarse sandstones which it contains throughout the Sharp Mountain, and indeed in both borders of the Pottsville Basin as far west as Dauphin. It possesses here even less of the Sharp Mountain or conglomerate type than it exhibits in the Shamokin Basin still further north-westward.

At *Klinger's Gap, Wiconisco Basin,* there is an alternation of conglomerates, from pea to egg in coarseness, with fine and coarse sandstones, under a thickness of about . . . 230 feet.

To this succeeds a group of four coal-beds, divided by pea, and pea and nut-conglomerates, and fiue and pebbly sandstones, the whole possessing a thickness of . . . 400 „

These two groups, in 630 feet of strata, represent the main lower group as it is developed at Bear Gap.

Eastern Middle Coal-field, Hazleton and Beaver Meadow Plateau.—Here the conglomeritic group possesses a considerable thickness, though this is not susceptible of accurate determination. As seen at several points on the southern margin of the plateau, it is estimated to be not less in thickness than . . . . 700 „

Mahanoy Basin, Ashland Gap.—In the gap of the Mahanoy Mountain at Ashland there is a great development of the conglomerate rocks. The pebbles are silicious, and of sizes ranging from pea to egg. Estimating its thickness from the top of the red shale to the lowermost coal-bed, it is not less than . . . . 600 „

If a ponderous bed of egg-conglomerate immediately overlying the bed of coal be included in our estimate, the total thickness will be . . . . . . 800 „

In *Shamokin Gap.*—In the Shamokin Mountain, at the village of that name, the lower or conglomeritic group of coal-measures—restricting its limits, as we have done elsewhere, to the top of the hard rocks below the fifth seam of coal ascending, which is very generally the commencement of the softer coal-measures—consists of an alternation of ribs of nut, coarse conglomerates, pebbly and fine-grained sandstones, with coarse shales and coal-slates in about equal proportions. It is made up of five of the hard silicious strata and four of the softer argillaceous, each of the latter including a bed of coal : some of these are of good quality and thickness. The whole group has here a thickness of . . . . 630 „

In *Zerbe's Gap, at Trevorton,* we see the most western natural section of the conglomeritic coal-measures in the Shamokin Basin. Here the group has a thickness of about . . 500 „

The mass consists of five ponderous strata of silicious conglomerate and coarse sandstone, and four thick beds of argillaceous shale and slate in regular alternation with them—the two kinds of rocks in about equal quantity. Each argillaceous member encloses a thick and valuable bed of semi-anthracite. In this western end of the Shamokin Basin these coals of the conglomerate group are far thicker and of higher average purity than anywhere else in the corresponding part of the coal-measures around the anthracite region.

In the *Northern Anthracite,* or *Wyoming and Lackawanna Coal-fields,* the formation consists of two strata, the lower chiefly a nut, coarse conglomerate of quartz and grey sandstone pebbles ; the upper a mass of dark-grey sandstones, sometimes pebbly. The average thickness of the lower stratum on the south-east side of the basin is 70 to 80 feet ; on the northwest side it is not more that 40 feet. The upper bed measures from 60 to 90 feet.

At *Scranton* the coarse lower rock is	80 feet.	
The upper fine-grained is	70 „	
		150 „
At *Plane 7, Roaring Brook, Cobb's Gap,* the nut conglomerate is . .	45 „	
The sandstone, ...	45 „	
		90 „
At *Solomon's Gap,* the lower is	80 „	
The upper, ...	90 „	
		170 „
On *the north side of the valley,* at Hertzog's Hollow, back of Kingston,—		
The upper rock is	60 „	
The lower, ...	40 „	
		100 „

In *Troy Gap*, back of Troy, the upper is 50 to	60 feet.	
The lower, ...	50 „	
	——	110 feet.
At *Warrior Path Gap*, west of Solomon's Gap, the lower (conglomerate) is	75 „	
The upper (sandstone), ...	60 „	
	——	135 „
At *Nanticoke*, Susquehanna Gap, the nut conglomerate is		30 „
NORTH-WEST BELT.		
Near *Astonville*, the lower or true conglomeritic rock, consisting in part of sandstone, in part of pebbly rock, has a thickness of . . .	45 feet.	
Upon it rests a coarse pebbly sandstone, which is . . .	25 „	
But between them is a coaly and bituminous slate, of the thickness of .	2 „	
	——	72 „
In the Hill at *Cartersville*, the Seral conglomerate consists of a pea conglomerate of	45 „	
And a pebbly sandstone, which is	15 „	
	——	60 „
At the *Ralston Old Mines* this interesting stratum has scarcely a thickness of 11 to . .		12 „
The conglomerate itself is hardly		8 „
In *Broad Top Mountain*, near the Juniata River, the thickness of the Seral conglomerate is not		100 „
FOURTH BELT.		
At *Blossburg*, the Seral conglomerate group consists of a very white sandstone, measuring	20 feet.	
Surmounted by a pea conglomerate, which is . . .	7 „	
	——	27 „

Survey of the Formation.—None of the land-derived or mechanically-formed sediments of the Appalachian Basin exhibit so remarkably regular a gradation of declining thickness, or quantity of material in a definite direction, as this great sheet of gravelly matter underlying and including the lowest coal-beds of the main or Seral coal series. It seems to thin faster towards the W.N.W., rapidly at first, but beyond the anthracite region very gradually.

BOOK I.

PRIMAL AND AURORAL STRATA OF THE ATLANTIC SLOPE.

In the South-eastern District, or Atlantic Slope, the only Palæozoic formations are, as I have already indicated, those of the Primal and Auroral series, which I shall now proceed to describe, pursuing the general order adopted throughout this work—that is to say, commencing with the most southern hills, and passing through each tract from the N.E. to the S.W.

DIVISION I.

PRIMAL SERIES.

INTRODUCTION.

The three great divisions or formations of the Primal Series—the Primal Older Slate, Primal White Sandstone, and Primal Newer Slate, which appear within the limits of Pennsylvania, are not all present in each belt where the series is exposed. In the more south-eastern zones especially, the Primal Upper Slate, and in some localities the Primal White Sandstone, would seem not to have been originally developed, or to have been deposited interruptedly. Even where present, the distinct recognition of the slates is rendered, in many cases, very difficult, as already shown, from their close approximation, in aspect and composition, to the more ancient metamorphic schists. Some uncertainty must, therefore, remain in regard to the exact position of the lines of boundary between the two systems of strata in the more altered belts, that especially which is in contact with the southern Gneissic tract in Lancaster and York counties. It is obvious, from evidence already adduced, that the primal strata once overspread the southern Gneissic region much more extensively than they do at present, those portions only along the southern border having been preserved from the general denudation, which were protected by lying in the synclinal troughs of the more ancient rocks.

CHAPTER I.

PRIMAL SERIES.—THE SOUTHERN BELT.

This southern outcrop of the Primal white sandstone has been already described, as it is traceable from the vicinity of Trenton to that of the Schuylkill, along the northern side of the Gneissic belt. It was stated to occur in a closely-folded synclinal flexure, and to lap round the end of the altered Auroral limestone in the neighbourhood of Willowgrove, the southern and longer line extending through Barren Hill to the Schuylkill. This outcrop exhibits the stratum in a more thoroughly metamorphosed condition than it anywhere else presents. Though it has not lost the regular and parallel bedding distinctive of the formation, it has undergone an almost total alteration of its lithological aspect and character, bearing less resemblance to a fine-grained sandstone than to some varieties of quartzose felspathic gneiss. Its structure is decidedly crystalline, and we frequently recognise in it a large proportion of well-developed felspar, not however so entirely insulated from the quartz as in typical gneiss or granite. It would seem, indeed, to have experienced just that degree of semi-fusion requisite to develop an imperfect felspar, but insufficient thoroughly to melt the silicious sand which is in a measure diffused through the felspathic mass, without much influencing the crystalline condition of this latter, very much as the sand occurs in the Fontainbleau carbonate of lime. So gneissoid is the aspect of this rock, as it appears at Barren Hill and other localities, that it has generally been regarded by geologists and mineralogists as a true Primary rock, and has even been regarded as a variety of Eurite. It is traversed by innumerable joints, which divide it into small rhombic masses. In the Barren Hill range, as far indeed as the Delaware, the stratum in the main consists of thin-bedded altered sandstone, and, in the upper portion, much altered slate; the Primal Newer Slate having a talcose and felspathic character. The massive thick-bedded more purely silicious part of the Primal white sandstone appears not to enter into the formation in this south-eastern belt, and hence the absence of the vitreous quartzose beds seen in other regions where that type of the rock has undergone the same extent of metamorphosis. It is an instructive fact connected with the change of constitution in this stratum, that it is in contact with very few trappean dykes or granitic veins of any kind. Like many other instances of metamorphosis on a large scale, it seems rather to have been caused by a general or diffused heat—most probably by the escape from within the crust, through innumerable joints and crevices, of a copious and perhaps often-repeated stream of intensely-heated volcanic gases and vapours. That we discover in this altered rock no traces of organic remains should not surprise us, since so few species of fossils have been as yet detected in the whole Primal series anywhere, even in those districts of the United States where the strata have been least affected by igneous agency.

The disappearance of the narrow Primal zone at the Schuylkill, in its course towards the west, is probably the result of an actual thinning away of the formation, which throughout this line is of very limited dimensions. Upon the northern border of the limestone, the Primal white sandstone and Primal newer slate occupy the western and southern slopes of the North Valley Hill, the whole distance from Valley Creek, near the Schuylkill, to Back Township in Lancaster

County, the lower beds of the sandstone being in contact with the gneiss which skirts it on the north. Between the point at which the northern branch of the eastern belt disappears, about half a mile west of Willow Grove, and its reappearance at Valley Forge, it is nearly hid by the unconformable overlapping of the Mesozoic red sandstone, beneath which it is probably continuous. Along the North Valley Hill, the sandstone contains a larger proportion than further eastward, of purely silicious beds ; it is even here much indurated and altered by heat, some of its layers containing minute needle-shaped crystals of hornblende, and a little crystallised talc, the evident products of segregation. The general dip of the strata is at an angle of about 70° to the south, identical with that of the immediately overlying limestone. The whole mass may be distinctively recognised in the notches which give passage to both the East and West Branches of the Brandywine, and also at the pass by which the Philadelphia and Columbia Railroad turns northward from the valley towards Mine Hill. At some of these natural sections, the thickness of the sandstone disclosed is about 100 feet, and that of the overlying Primal newer slate perhaps a little greater. These rocks appear to have covered, at one time, nearly the whole of the northern Gneiss region of Chester County, for isolated hills of it occur in several localities.

It is thus found in small outlying patches near Valley Forge and between Downingtown and Mainesburg, and other places between the North Valley Hill and the Welsh Mountain.

Between the township of Honeybrook and West Caln, commencing near the Lancaster turnpike, above Wemer's Mill, and extending westward nearly as far as the county line, there is a steep hill consisting of this formation. On the road from Downingtown to the Red Lion, in the lower part of Uwchlan Township, the same rock occurs, in a small isolated hill running north-east and south-west for about a mile. We have already mentioned the occurrence of a similar detached hill of this sandstone near London Grove. Another, called the Buckingham Mountain, occurs near Centreville in Bucks County.

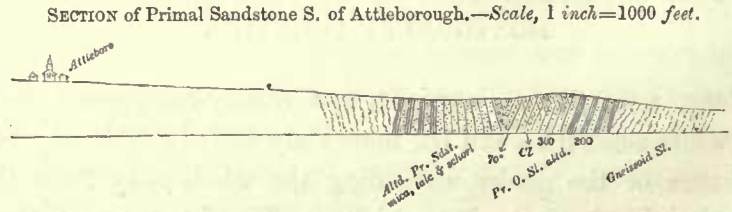
RANGE OF THE SOUTHERN TROUGH OF PRIMAL ROCKS IN BUCKS AND MONTGOMERY COUNTIES.

There exists a long, narrow, very straight, and closely-compressed trough of the Upper Primal Rocks, or the white sandstone, and the more slaty beds immediately beneath it, in a compressed synclinal flexure of the gneiss, extending the whole way from the Delaware below Trenton to the neighbourhood of the Wissahickon. The hardness of the Primal sandstone especially when highly altered by heat, as in the Belt before us, compared with the less cohesive Micaceous Gneiss, has caused this synclinal outcrop or trough to stand above the general plain of the country, especially of the district south of it, in the form of a low and very regular ridge. In Bucks, and even Montgomery County, this is very generally called "Edge Hill Ridge," under a mistaken but common impression that it is a prolongation of the hill bearing that name, which constitutes the southern boundary of the limestone basin E. of the Wissahickon. But this latter, as will be seen by a glance at the Map, or a perusal of succeeding paragraphs, terminates near the Pennypack, a mile or more to the north of the belt now under description. The two ridges are, in fact, not connected except at their origin E. of the Wissahickon, where the anticlinal ridge of Barren Hill subdivides, by the intrusion into it from the E. of an anticlinal tongue of gneiss, sending forward its north-dipping outcrop in the sharp monoclinal north-dipping Primal rocks flanking Edge Hill, and forming with this the compressed synclinal trough of the long belt which we are tracing. From this point of divergence of the two ranges, which is about 2 miles E. of the Wissahickon, this belt of rocks, trending less toward the N. than the true Edge Hill, passes about one-fourth of a mile S. of Edge Hill village, and just S. of Mooretown, and ranges thence across the Pennypack near Walton's Mill. From this point it maintains its course E. about 16°. N., and runs on to Brownsville in Bucks County, this village being situated just at the southern base of the ridge. Crossing the Neshaminy at Mather's Mill, it passes S. of the village of Attleborough, the crest of the ridge, or probable synclinal axis, being just about one-half of a mile from the village. Thence it extends through Oxford, and a little N. of Fallsington, and reaches the west side of the Delaware River just below Morrisville, where its strata are well exposed in a quarry near the river-side. From this point it pursues the same straight course through the wide channel of the Delaware, in which it forms a ridge or ripple, and receding from the river-bank in New Jersey, loses itself from view under a covering of drift and sand.

The general structure of this long and regular belt is everywhere very simple, being that of a nearly perpendicular synclinal fold, in which the strata of the two sides of the trough are compressed into approximate parallelism with each other, dipping at very steep angles, and in some places even in the same direction. An inversion of the southern side of the trough, though a frequent, is not an invariable feature, some of the sections across the ridge exhibiting these beds dipping steeply to the N.; but in such cases, always at a higher angle than that at which those of the northern side of the axis dip southward. In other words, the axis plane is not perpendicular to the horizon, but invariably dips steeply to the S.S.E.

The composition of this most southern of all our outcrops of the Primal strata is well seen on the road leading into Attleborough from Bristol. Passing from the Gneiss at the southern foot of the Sandstone Ridge, the Primal strata present themselves under the following aspects and dimensions:—

Section of Primal Sandstone S. of Attleborough.—*Scale*, 1 *inch*=1000 *feet*.



Immediately succeeding the gneiss, there occur, on the southern slope of the ridge, a group of highly altered slates of the older Primal division. These are semi-crystalline, and contain much segregated felspar and mica. The group is between 200 and 300 feet thick. Over these, which may be seen in the trenches at the road-side, dipping very steeply towards the N., is the Primal white sandstone formation, which, as usual throughout this belt, indicates an extreme degree of metamorphism. The rock is very quartzose, and in some layers even semi-vitreous, and it contains mica, talc, and schorl in the thin partings which separate its beds. Surmounting these sandstone strata, or succeeding them in the centre of the ridge at the synclinal turn of the dip, are intercalated beds of white quartzose conglomerate, the pebbles generally not exceeding the size of a boy's marble. These hardest layers occupy the crest of the ridge. The visible thickness of the white sandstone from the slate on the one side, to the synclinal axis on the other, is about 300 feet, and this may be given as the approximate depth of the formation generally in its course through Bucks County. It becomes perceptibly thinner as it ranges westward towards the Wissahickon, for on the Limekiln Turnpike, S. of Edge Hill village, the whole formation, well exposed in a deep cut, shows a thickness not exceeding 150 feet.

Owing to the amount of metamorphic action to which this belt of sandstone has been subjected, its strata possess a firmness of cohesion, and a tendency to lamination, which, combined with the original thinness and parallelism of its bedding, allow it to split up in quarrying into slabs or flagstones of unusual size, regularity, and strength. The rock is therefore extensively employed throughout the adjoining rural districts as a flagstone for steps, walks, and especially for dairies or milk-vaults.

A prevailing structural feature throughout all this zone of altered Primal strata, is a system of cleavage planes, which dip invariably at a steep angle, 70° or 80° to the S.S.E., whether the strata themselves dip in that direction or not. This, be it observed, is the almost universal direction of the cleavage-dip throughout the Atlantic Slope.

The following is a list of some of the principal quarries of flagging and building stone at present resorted to in this Ridge. None, it would seem, have been opened to the W. of the Pennypack, in consequence, apparently, of a reduction in the hardness of the rock, from abatement of metamorphic action in that direction. The two or three quarries E. of the Neshaminy, including that at Morrisville on the Delaware, are not here embraced.

PRINCIPAL QUARRIES IN THE SOUTHERN BELT OF PRIMAL SANDSTONE BETWEEN THE NESHAMINY AND THE PENNYPACK.

1. *Franklin Vansant's*, near the Neshaminy, on the south side of the Ridge. This is a large quarry.
2. *Mahlen Hicks's*, three-fourths of a mile west of Vansant's, also on the south side of the Ridge. It contains a harder stone than that quarried by Vansant. The flags are thin and smooth.
3. *Mahlen Ridge's* quarry is situated 300 yards west of Hicks's quarry. It is a large one, yielding larger flags than any of the others. Stones can be procured measuring 6 feet by 8, and 4 by 6, and having a thickness frequently of from 2 to 6 inches. This quarry is half a mile east of Brownsville.
4. Capt. E. Groom, Benj. Knight, and Mr Lerdom, all have quarries about half a mile west of Brown's Mills. All three yield a stone quite similar to that of Vansant's, of a yellowish white colour, and thicker flags than those from Hicks's, there being much good building-stone.
5. Silas Rhoads and Samuel Acops have two quarries on the south side of the Ridge, near the Bustleton Turnpike. These quarries yield stone like those next east—a good building-stone, but a less proportion of large flagstone. The best building-stone is from the quarries of Groom, Knight, and Lerdom.

There are no other quarries opened in Bucks County to the westward. All the flagging-stone produced is immediately bought up. It sells at the quarry for $1 per horse-load. The building-stone is sold at about 12½ cents per perch. The *best* description of building-stone at the quarry costs 20 cents per perch.

GENERAL GEOGRAPHICAL LIMITS OF THE PRIMAL STRATA WEST OF THE SCHUYLKILL, AND SOUTH OF THE CHESTER COUNTY LIMESTONE VALLEY.

In describing the geographical distribution of the older Primal Slates south of the Chester County Valley and west of the Schuylkill, no difficulty presents itself in defining their Northern limit, which coincides very nearly with the Northern base of the South Valley Hill, or, in other words, with the Southern margin of the limestone of the valley, the interposed Primal white sandstone being, as already mentioned, very thin. Nor is there any obscurity in the boundary between this slate belt and the gneissic rocks to the south of it from the Schuylkill to the Brandywine, this line having been already defined as that of the Northern edge of the gneiss. But to the westward of the Brandywine a difficulty does present itself, from the introduction of a number of troughs included between the series of narrow tapering anticlinal belts, or fringes of gneiss, by which the Primal series is spread prodigiously to the southward, almost to the Southern line of the State. If the actual limit between the lowest Primal rocks and the gneiss could be minutely followed, it would be found to wind in and out, in a zigzag manner, between the uplifted spurs of gneiss, each successive trough to the S. lying somewhat further towards the W. than the preceding one. The general line of boundary is represented on the Geological Map; it is designedly somewhat vague. Looking at the entire area occupied by these Primal rocks, between the Schuylkill and the Susquehanna, and between the Pecquea and Conestoga valleys and the Maryland State line, we are reminded of the form of a hatchet or cleaver, the long slender belt between the Schuylkill and the Western Branch of the Brandywine representing the handle, and the wide slate district of the South-western townships of Chester, and of the Southern ones of Lancaster, representing the blade.

The Southern limit of the Primal slates within the State is the Northern edge of the long tract of Serpentine, under the State line in Lancaster; but other narrow ranges occur in Maryland, before we reach the main district of gneiss. Progressively expanding in its range south-westward, the belt of older Primal rocks is even broader in York County than it is in Chester and Lancaster; and in Maryland it is wider still.

COMPOSITION OF THE PRIMAL STRATA AS THEY ARE DEVELOPED IN THE MONTGOMERY COUNTY VALLEY, EAST OF THE SCHUYLKILL RIVER.

It is only on their Northern outcrop, or that extending eastward from the Wissahickon towards the Pennypack Creek, that we find the Primal rocks wearing a resemblance to their ordinary sedimentary aspect, undisguised by metamorphism. There the principal mass is an alternation of thin beds of bluish grey sandstone and still thinner layers of brownish sandy slate, very much the type which the older Primal rocks exhibit on the Susquehanna above Columbia. A partial metamorphism is observable, however, even in this Northern outcrop, for the most argillaceous, or slaty partings, present oftentimes the aspect of an incipient talcose crystallisation.

Along the Southern border of the Limestone Valley, all the Primal rocks wear a greatly more altered character; the lower beds, or those adjoining the gneiss, presenting indeed so advanced a condition of crystallisation as to be entitled to the name of Semi-Porphyroidal Rocks. On a first inspection, especially of the weathered and disintegrated outcropping fragments of these lowest Primal beds, the observer is very liable to confound the formation with the uppermost hornblendic felspathic layers of the adjacent genuine gneiss; and until my own researches enabled me carefully to study and trace the several strata of this zone, the propriety of referring these porphyroidal beds to any system of rocks newer than the Gneissic formation, was never, I believe, entertained.

In the district of the Schuylkill and Wissahickon, the three members, of which the Primal series there consists, present the following aspects and dimensions.

The *lowest*, or semi-porphyroidal group, evidently an altered sandy slate, or argillaceous sandstone, is remarkable for the regular parallelism of its lamination and bedding; the laminæ, alternately light and dark, being exceedingly thin, many of them usually packing within the thickness of an inch. These laminæ consist, where the rock wears its most metamorphosed form, of white earthy, imperfectly-developed felspar, and perfectly-developed earthy hornblende. Besides these alternate whitish and dark streaks, the cross fracture of the rock displays a multitude of ovoidal concretionary crystallisations, generally only specks in size, but sometimes of the dimensions of bullets, the larger and better formed concretions being frequently genuine crystals of felspar. In some of the layers certain laminæ are studded with isolated crystallisations of hornblende.

The maximum thickness of this group at the Schuylkill is about 300 feet; but not more than 100 feet can be seen immediately at Spring Mill.

The *next* rock ascending, or the second member of the Primal series, is a species of imperfectly-formed talcose and micaceous slate. When most metamorphosed, it consists of wavy, nearly parallel laminæ of quartz, mica, and apparently some talc, with innumerable crystals of dodecahedral garnet. It exhibits this composition near the mouth of the ravine of Aramink Creek, opposite Conshohocken. The twisted or wavy form of the plates of mica seems due, as in the coarse mica-slates of the true gneissic series, to the interference of the garnets and of the segregated quartz. When less altered, these strata have the characters of an impure sandstone, pervaded with particles of imperfectly-developed mica and talc. This rock is very liable to disintegrate from exposure to weather; it decomposes into an unctuous talcose earth, of a mottled deep-red and blue colour, forming a highly ferruginous soil, a chief source from whence the percolating waters extracting the oxide of iron have formed those large deposits of brown hæmatitic iron-ore that adjoin the outcrops of the Primal and lower Auroral formations. The very abundant fragments of white quartz, resembling a pale chert, which strew the surface near the outcrop of this second member of the Primal series, are not fragments of genuine injected quartz veins penetrating the strata, but merely large segregations of the quartzose matter of this rock consequent upon its alteration by heat. Such plates of fine-grained cherty quartz, sometimes including imperfectly-developed felspar, may readily be mistaken at first glance for the more quartzose felspathic layers of the altered Primal white sandstone of the range of Barren Hill. The apparent thickness of this middle member of the Primal series is here about 200 feet.

The *third* and terminating rock of the Primal series near the Schuylkill is the white sandstone above mentioned, so conspicuously exposed in the anticlinal ridge of Barren Hill. It is a thin-bedded, yellowish white, very compact rock, presenting in composition much imperfectly-developed felspar, and showing a tendency to a rhombohedral fracture. The more solid layers seldom exceed two inches in thickness. Other more schistose bands, consisting of the same quartzose felspathic matter in intimate fusion, contain likewise many minute partings of crystalline mica and talc, and the surfaces of the more solid felspathic beds exhibit very frequently at these partings innumerable minute crystalline specks of pure black schorl. This rock possesses a thickness in Edge Hill, Barren Hill, and near the Wissahickon, of 35 to 40 feet; but further eastward the group is far more massive, being, in the vicinity of Willow Grove, not less probably than 100 feet thick, and in Bucks County, in the southern trough, not less than 300 feet.

LOCALITIES WHERE THE PRIMAL ROCKS MAY BE BEST STUDIED.

On the Southern side of the basin, *the lowest, or semi-porphyroidal group*, is well exposed for observation in the ravine of the Aramink, and thence at the base of the river-hills eastward to the Ferry House opposite Spring Mill; again in the point of the hill at Spring Mill, just North of the William Penn Iron-Furnace. It has been laid open to view by quarrying, at the entrance of the Wissahickon into the gneissic hills, and again at the foot of Chestnut Hill, on the Germantown and Perkiomen Turnpike. It is a material very well adapted for macadamising the turnpike roads, being tough and durable, while it is easily quarried.

Fig. 9.—Section on Aramink Creek.

The Second Division of the Primal Series, or the Mica-Talcose Group, is best exposed along its Southern outcrop, at and near the mouth of the Aramink Creek. Elsewhere upon this line it is generally covered by surface matter. Its fragments are abundant in the soil upon it. Ranging as it does immediately at the foot of the Gneiss Hills, it is very generally concealed by the rubbish of the rocks higher on the slopes behind it.

The same obscurity attends this southern outcrop of the *upper Primal rock*—the White Sandstone; but a fair exposure of this exists in the vicinity of Spring Mill, immediately on the road at the base of the Furnace Hill, where a large and old excavation for iron ore has revealed the stratum and its steep Northern dip. But the best exposures of the Primal white altered sandstone are at the several cuts through the Barren Hill ridge, formed for the passage of the turnpike roads. Perhaps the completest of all is at Edge Hill village, where the whole formation is finely developed in a deep cut on the northern Pennsylvania or Water-Gap Railroad. Some of the upper beds of this rock are beautifully developed in an excavation on the South side of the anticlinal of Barren Hill, adjacent to the village of Spring Mill. It may be well seen, under the modifications induced in it by cleavage, in the end of the Church Hill at Whitemarsh.

Along the Northern side of the basin, the lower groups, in their unaltered aspect of sandy slates and argillaceous sandstones, are best beheld near Sandy Run, especially in the deep cut in that vicinity for the Northern Pennsylvania Railroad. Further to the eastward the Primal white sandstone sheets the Southern slope of the same Northern boundary of the valley, and is fairly exposed on two or three of the cross-roads of the country.

COMPOSITION OF THE PRIMAL STRATA IN THEIR DISTRIBUTION WEST OF THE SCHUYLKILL.

When the Primal rocks W. of the Schuylkill and S. of the edge of the red sandstone, are carefully studied, they exhibit as remarkable a constancy in the characters of the white sandstone member, as they present aberration in the lithological type of the other or slaty groups.

Primal White Sandstone.—The sandstone retains throughout its entire distance to the Susquehanna, almost identically, the features which distinguish it in Montgomery County. It presents, that is to say, in those outcrops where it has undergone the greatest amount of metamorphism, a semi-vitreous texture, specks of imperfectly-developed felspar, partings delicately coated with white talc, and surfaces imbedding minute segregated crystals of schorl. In its less altered belts, especially those north of the Chester County Valley, as the north Valley Hill and the Welsh Mountains, the sandstone is ordinarily less firmly cemented, and therefore more extensively crumbled and eroded along its outcrops, more porous and softer, and less divisible into thin flags; it contains, moreover, but little segregated talc or schorl.

Primal Slates.—But when we trace the slates of the Primal series, in our progress to the W. or S.W., we find that they are not so persistent in their characters, but put on some new and interesting features, losing others which are distinctive of the group to the eastward of the Schuylkill. Thus the peculiar speckled and semi-porphyroidal group of beds, at the very base of the whole Primal series, in contact with the gneiss at the Schuylkill, is less distinctly recognised as we follow the boundary between the two systems of rocks westward for a few miles. We may still detect it, though more obscurely, S. of the Paoli; but we cannot recognise it when we reach the Brandywine. This change may be due either to the running out of this division of the formation by loss of material, or it may result from a change in the conditions of metamorphism arising either from a modification in the original composition of the stratum, or from a more intense and prolonged exertion of subterranean heat. The form of rock which replaces the dark semi-porphyroidal beds at the base of the Primal series, and therefore of the whole vast Palæozoic system, is one which well deserves to be critically studied and noted. It is a variety of silicious, talco-micaceous slate. In certain districts W. of the Brandywine, especially towards the Susquehanna, where the metamorphic action seems to have been in its highest energy, the crystalline character of these rocks is at its maximum, and it is there sometimes difficult to distinguish the strata from certain forms of the more micaceous beds of the true Gneissic or Hypozoic system. An extensive comparison, however, of the materials of the two formations, enables one almost invariably to determine definitely between the real micaceous slate and that which only simulates it.

It is impossible to subdivide into its several component members the Great Lower Primal Group of Southern Pennsylvania, W. of the Schuylkill River, for the more we study it in detail, the more nugatory become our efforts to trace the separate strata or determine their stratigraphical relations. This difficulty proceeds from several causes: first, a pervading transverse cleavage, which extensively effaces all clear traces of the original bedding; secondly, the presence of innumerable plications, often so closely compressed as to appear as only one uniform dip, the anticlinal and synclinal foldings in many cases escaping detection through the obscuring influence of the cleavage; and, thirdly, mutations in the composition, or at least in the now prevailing crystalline or metamorphic constitution of the beds.

Defining, then, the entire succession of slaty rocks embraced between the upper limit of the genuine Gneiss and the bottom of the Primal white sandstone, as one natural group, it will be best represented as an alternation of talcoid silicious slate, talco-micaceous slate, and quartzose micaceous rock, usually also schistose, or thinly laminated. Along the Northern side of the tract occupied by these older Primal rocks—that is to say, adjoining the great limestone of the valley on the south—the principal form which the stratum assumes is that of a talcoid slate, full of lenticular lumps of granular quartz, apparently the silicious material in excess, in a state of segregation. This form of the fragments prevails especially where the cleavage, always dipping to the S.E., is not coincident with the bedding. In the rarer instances where these two sets of planes do concur, the lamination is more parallel, and the silicious granules more dispersed among the talc. Alternating with the talcose slates are beds of the more micaceous variety; but the more highly micaceous, silicious schists, prevail chiefly in the lower half of the formation, or, as respects the belt in question, in its central and southern portions.

Besides the talcose and the micaceous varieties of the metamorphosed Primal slates, there exists a third species of rock under the form of a nearly pure clay-slate of the character of roofing slate. This seems to occupy a horizon comparatively low in the series, for it is never interstratified with the talcose or upper division, but with the highly-crystalline micaceous rocks, which seem to prevail most in the central and lower.

DESCRIPTION OF THE SECTION ALONG THE BRANDYWINE.

(SEE ENGRAVED SECTION.)

A careful examination of the "Section along the Brandywine Creek" will render more evident than any general description can, the conditions under which the older Primal slates appear, as respects their crystallisation, cleavage, and dip, within this middle portion of the Southern Primal Belt in Pennsylvania.

Restricting our attention to the portions of the section south of the Chester or Downingtown Valley, it will be observed that talc-slate, with a steep northward dip of 80°, and an equally steep South-dipping cleavage, immediately succeeds the limestone a few hundred feet south of the railway station. From this point to the road leading to West Chester, about a thousand yards below the Bridge at Taylor's Ford, we have a succession of talc-slates and talco-micaceous slates, more or less quartzose, dipping for the most part southward, and full of South-dipping cleavage—with, however, occasional steep North dips, implying the presence of acutely-folded flexures. In one instance the cleavage also dips towards the north. This whole belt manifestly belongs to the older Primal slates. Between Taylor's Ford and Brinton's Run, or the vicinity of Chadd's Ford, the section crosses a complex belt, embracing much micaceous and hornblendic gneiss, with soft felspathic gneiss, under various conditions of dip, and irregularly alternating with micaceous and talcose slates, occasionally containing garnets. This alternation of the harder, more massive gneiss, with the softer, more loosely aggregated, and, to appearance, less perfectly developed, seems to mark the presence of two systems of rocks, an older or Hypozoic gneiss, and a more modern or Azoic series, probably the lower Primal slates in conditions of extreme metamorphism. I conceive that the most natural interpretation of the geological features of this district will be found in the hypothesis of a succession of narrow parallel anticlinal folds of the older gneiss, enclosing between them folded troughs of the newer metamorphic group, precisely as we recognise a similar series of anticlinal fingers and synclinal basins of the two respective formations in the region of the East and Middle Branches of the Whiteclay Creek further to the S.W. Grasping the whole of this part of Chester County in one general survey, I suppose it to contain a series of closely-compressed anticlinal and synclinal flexures—the anticlinal lifting the older rocks, the synclinal holding within them the newer, and disposed in echelon, or in oblique order; the more southern, as a general rule, terminating further to the west than the more northern. This conception satisfactorily explains the presence of the numerous parallel synclinal valleys of the still higher Auroral limestone, with their bounding outcrops of the Primal white sandstone, dipping conformably with the semi-gneissic or micaceous schists. It likewise accounts for the rapid horizontal expansion of the whole slaty Azoic region, from the Brandywine westward.

THE PRIMAL STRATA, AS EMBRACED IN THE SYNCLINAL VALLEY OF MONTGOMERY AND CHESTER COUNTIES.

These rocks lying in a trough of the great Gneiss formation, but unconformably upon its more contorted beds, consist of all the three older Primal strata which this part of Pennsylvania possesses, together with the chief part of the Auroral or magnesian limestone series. The Primal rocks form the border of the valley, the South side of which they fringe with a continuous belt, while they skirt the Northern side more interruptedly, ranging from the Eastern point of the trough, near the county line of Bucks and Montgomery, to the Wissahickon; and again, from Valley Forge continuously westward through Chester and Lancaster counties, the interruption in the region of the Schuylkill being by an unconformable overlap of the Southern edge of the Middle secondary red shale or Mesozoic red shale and sandstone. In the district E. of the Schuylkill, the Southern fringing belt ranges along the base of the Gneissic hills to beyond the Wissahickon; but from thence eastward they occupy a narrow ridge of their own, called Edge Hill. The Northern outcrop forms, from the Eastern head of the valley westward to the Wissahickon, the bounding ridge of this portion of the limestone valley. All the Eastern end of the trough, from a point about half a mile W. of the Willow Grove Turnpike, to near the Huntingdon Turnpike E. of Pennypack Creek, is underlaid by the Southern belt of the Primal rocks, the Auroral limestone terminating at J. C. Tyson's, E. of the source of Sandy Run, a mile to the S.W. of Willow Grove.

STRUCTURE OF THE EASTERN END OF THE LIMESTONE BASIN OF MONTGOMERY AND CHESTER, FROM THE WISSAHICKON TO THE PENNYPACK.

Some interesting features exhibit themselves in the structure of our great Southern limestone-basin towards its Eastern termination. Its most Eastern division, extending from the Wissahickon to the Pennypack, is regularly bounded by a Southern and a Northern ridge or belt of hard Primal rocks ; but these ridges do not coalesce, as would be the case if the basin was one of the most simple synclinal form, but they run on separately past the termination of the limestone in two independent and slightly-approaching crests, till they terminate about a mile apart in the vicinity of the Pennypack, the outcrops of the Primal strata being prolonged indeed across that stream nearly to the Huntingdon Turnpike. The whole trough ends in the form of a swallow's tail with the two prongs collapsed, as when the bird is darting. The included bed of limestone itself forks, but not into points as acute as those presented by the belts of Primal strata which confine it. One prong of the limestone valley prolongs itself eastward to within half a mile of Willow Grove, past the source of Sandy Run; while the other more Southern one, following the Northern base of Edge Hill, extends almost to the Willow Grove Turnpike. This forking of the end of the whole basin is the consequence of a complex anticlinal flexure of all the strata of the region prolonged from the eastward, across the Pennypack, between the two Primal spurs, and dying down in the eastern end of the trough of limestone. Its effect is to form two subordinate independent troughs in the eastern end of the one general basin, as exhibited on the Geological Map. Willow Grove is situated in the Northern synclinal valley on the Primal sandstone; while the Southern trough crosses the turnpike about half a mile S., the upper rocks at the crossing being the same white-sandstone group. Between these two branch basins of the Primal series, we find in reality a double and not a single anticlinal axis ; or in other words, the wave is concave on its crest. This is evident from the existence of two separate anticlinal belts or points of the gneissic rocks penetrating westward between the spurs of sandstone in the vicinity of the road connecting Blaker's Store and Morgan's Mill. These two anticlinal points of the gneiss enclose a synclinal ridge of the Primal rocks, the highest or capping stratum being the conglomeritic bed which terminates the white-sandstone group. Advancing westward as the two anticlinals subside, we discern at the turnpike only one broad flat arching of the upper Primal slates, lifted to the surface by the more southern and important of the two flexures. It is this line of elevation apparently which causes the broad swell of upper Primal sandstone, in which the limestone valley abruptly ends at Hollowell's and Tyson's farms. The more northern and feebler axis does not show itself in the topography to the westward of Willow Grove.

The extreme synclinal point or last visible trace of the more southern basin of Primal strata, or that of the true Edge Hill, is at the Huntingdon Turnpike near the Sorrel Horse Inn ; and the further exposure of the northern or Camp Hill belt, or trough, is on the same meridian, or road leading N.W. from the Sorrel Horse Inn. About half a mile to the eastward of this road, this belt of the Primal rocks is overlaid by the southern conglomeritic margin of the Middle secondary red sandstone ; but the belt itself very probably terminates near this point.

The following sections display the changing structure of the Primal belt in its progress Westward.

Fig. 10.—Section E. of Pennypack at Sorrel Horse Inn. (*Scale*, 1 *inch* = 2000 *feet.*)

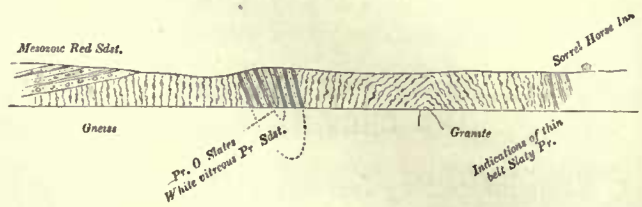


Fig. 11.—Section from Morgan's Mill to the west of Yerke's Factory. (*Scale*, 1 *inch* = 600 *feet.*)

Fig. 12.—Section of Primal rocks at Willow Grove Turnpike. (*Scale*, 1 *inch* = 1500 *feet.*)

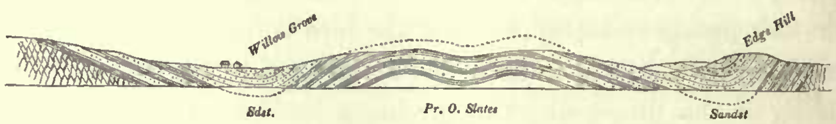


Fig. 13.—Section at Forking of Basin, near Tyson, west of Willow Grove. (*Scale*, 1 *inch* = 2000 *feet.*)

DETAILS RESPECTING THE PRIMAL ROCKS IN THE DISTRICT OF WILLOW GROVE.

On the Willow Grove Turnpike near Willow Grove, we may discern the structure of the whole Primal Zone as it is represented in our section. Just north of the forking of the Turnpike, we detect on the sides of both the roads the Primal rocks, leaning at a moderate angle upon the gneiss, dipping towards the little valley in which Willow Grove is situated. Crossing this valley to the road leading to Newtown, and ascending the hill forming the southern boundary of the same small valley, we find this hill sheeted over with the Primal sandstone, dipping to the opposite quarter, or to the north, and forming thus with the other outcrop the Northern Branch Basin. Here, upon the northern slope and end of this hill, the fragments of the sandstone contain numerous vestiges of *Scolithus linearis*, the fossil characteristic of the White Primal Sandstone. If now we advance along the turnpike southward, we may readily perceive the synclinal structure of the southern valley, or that at the northern foot of Edge Hill, by noting first the southward gentle dip of the upper layers of the Primal slates by the roadside, and presently a similar dip in the overlying white sandstones at the brow of the hill as we descend into the valley. Crossing the valley and the crest of its southern ridge, or Edge Hill, we may plainly see the same Primal rocks recur in the inverse order under an opposite and steeper dip to the northward.

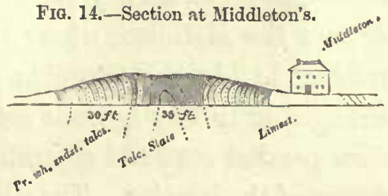
Further eastward the relative positions of the several belts of strata are disclosed to careful study in the line of our section, crossing the whole belt from Morgan's Mill to Yerke's Mill or Factory. At Morgan's Mill we find the lowest layers of the Middle Secondary Red Sandstone, under their usual condition of a very coarse conglomerate. A few hundred feet southward from Morgan's Mill on the road to Willow Grove, we have the gneiss emerging from beneath this margin of conglomerate; while across a meadow south-eastward, and by the road to Blaker's Store, we detect the northern synclinal belt or trough of the Primal sandstone dipping gently southward near Newport's house, and beyond this, on the road near his gate, dipping very steeply northward, constituting a narrow trough. If we advance south-eastward along this road, we will detect a second belt of the gneiss occupying a breadth of several hundred yards, until, near the intersection of this road with that leading to Shelmire's Mill, we encounter the eastern point of a synclinal hill of the Primal sandstones. Near this intersection of roads is a second anticlinal axis, which, between the Pennypack and this point, lifts to the surface the older Gneissic rock, but which here, and to the westward, only elevates the overresting Primal slates. At this part of our section, where it crosses the road running from Edge Hill to Shelmire's Mill we come upon the conglomerate beds which in this neighbourhood terminate the Primal series. These cap the synclinal hill already mentioned, and likewise the two spurs to the south of it, which are only the two outcrops of the hard Primal rocks that here form the Southern or Edge Hill basin. Both these latter ridges are abruptly cut down at their eastern ends by transverse erosion, the point of the basin of upper hard Primal rocks being here nipped off.

Tracing the northern synclinal line of the Primal rocks eastward from near Morgan's Mill, we follow it through a hill lying eastward of Newport's house, and detect it at several points till it crosses the Pennypack, and leads along the northern brow of a ridge half-a-mile to the north-west of the Sorrel Horse Inn. In this ridge we may detect the lower or slaty Primal rocks in a highly metamorphic condition, approximating in their aspect and crystalline condition to a rather finely-laminated gneiss, with some beds of which they are in contact. In the centre of a close synclinal fold of these slates the white Primal sandstone is seen densely cemented and very vitreous, and only about twenty feet in thickness, all the upper beds having been cut away. In this synclinal fold the strata dip about 60° to S. As already mentioned, the red sandstone conceals the termination of the strip of Primal at a short distance beyond this spot to the east, or before it reaches the county line of Bucks and Montgomery.

PRIMAL STRATA WITHIN THE AURORAL LIMESTONE VALLEY OF MONTGOMERY AND CHESTER COUNTIES.

First Anticlinal lifting the Primal Rocks.—Besides the Northern and Southern fringing outcrops, and a long contracting Eastern belt, in which the trough terminates, there occur two or three anticlinal uplifts of the Primal rocks within the outer limits of the limestone of the valley. The most southern of these insulated tracts is the narrow belt of Barren Hill, a prolongation of Edge Hill, which range is but a monoclinal outcrop of the Primal white sandstone and its underlying slates lifted into a perpendicular dip by an anticlinal flexure in the gneiss immediately behind it to the S. The axis of this anticlinal wave is prolonged all the way to the Schuylkill, gradually subsiding westward till it permits the upper Primal white rocks to bury themselves near Spring Mill under the overlying Magnesian limestone. It is a closely-compressed or sharp anticlinal, elevating the gneissic rocks to the surface as far westward along the sinking crest of the Edge Hill ridge as the vicinity of Heydrick's Mill, on the road leading from the Bethlehem Turnpike towards Willow Grove. Westward of this point of depression in the ridge, no gneiss is visible in its axis, but only the uppermost layers of the older Primal slates, which are here more or less talcoid from metamorphosis by heat. Even these talcoid layers sink out of view before we reach the village of Barren Hill, from a point E. of which, to the village of Spring Mill, the only rock exposed along the summit and flanks of the ridge is the *white Primal sandstone* in a highly felspathic condition, with talcose partings.

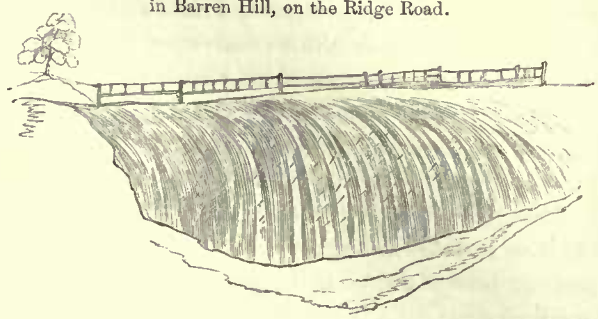
FIG. 14.—Section at Middleton's.



A section of this compressed flexure is exposed in a cut on the turnpike road at Middleton's. It is interesting as showing a bending of the outcrops of the strata both ways down-hill, from the pressure of retreating waters.

Barren Hill presents us with some striking examples of overturned outcrops, from the mere effect of the pressure induced by the denuding waters during their diffused rapid subsidence at the time the land was uplifted. It is both there and in many other parts of Pennsylvania on far too great a scale to be attributable to the softening action of rain and hill-side pressure.

FIG. 15.—Overturned outcrop of Primal Sandstone in a quarry in Barren Hill, on the Ridge Road.



Between this anticlinal of the Primal rocks and the base of the Gneissic hills to the south, there lies a narrow parallel trough full of exquisitely-beautiful local scenery, its soil a deep covering of fertile earth derived from the Gneissic and Primal strata. This little synclinal valley appears to contain here and there patches of the lower beds of the Auroral magnesian limestone; but the outcrops of this rock are difficult to detect in the earthy covering above mentioned; and it is more than probable that the trough is too shallow to contain any long continuous belt of it. The limestone is detected resting on the Primal white sandstone, in a south dip close by the Toll Gate on the Wissahickon and Perkiomen Turnpike at Middleton's.

Second Anticlinal of Primal Rocks.—The next anticlinal belt of insulated Primal rocks within the Limestone Valley east of the Schuylkill River, is a long narrow range of the Primal older slates in a more or less talcoid condition, which, commencing at this river at Conshohocken, and extending eastward, contracts, and finally subsides at the Perkiomen turnpike south of Marble Hall. This uplift of the Primal strata through the Magnesian limestone is simply a prolongation of the bold anticlinal fold of the lower rocks of Bethel Hill, west of the Schuylkill, opposite Conshohocken. It evidently originates in the plateau of gneiss to the westward. Sinking to the eastward across the Schuylkill, it insulates a trough of the Magnesian limestone between it and the belt of the gneissic hills bounding the river between Conshohocken and Spring Mill; and beyond the Western head or termination of this limestone basin, insulates between the gneiss which the anticlinal there uplifts, and the main Southern gneiss, a similar contracting trough of the Primal slates. It is along this trough of the slates that the upper part of the Gulf Creek flows, until it breaches the anticlinal, and passes northward through the deep gorge called "The Gulf." The axis, or back of the wave, is probably prolonged to the eastward across the Wissahickon, for apparently a couple of miles beyond the Perkiomen Turnpike, near which the talcose slates seem to sink under the limestone. Even on the Bethlehem Turnpike a ridge in the limestone, directly in the prolongation of this axis, betrays in its structure and soil the presence of this anticlinal wave.

It is worthy of remark, that all the marble of the limestone basin of Montgomery County is confined to the synclinal trough adjoining the anticlinal axis now described, upon the N.; the genuine marble not extending more than half a mile from the uplifted belt of slate, nor eastward in its line of strike beyond the neighbourhood of the point of sinking down of the Primal slates, or past the Meridian, where the anticlinal rapidly loses its force. As the marble is evidently only a highly metamorphic variety of the ordinary Magnesian limestone, crystallised and changed in tint by igneous action from within the earth, it is quite natural that it should run thus parallel with and adjacent to this line of uplift, produced as this has been by the protruding forces of the interior. The whole of this belt of marble is in fact but the vertically upturned, and occasionally inverted, Northern side of this anticlinal wave, the side along which the maximum amount of igneous influence is invariably manifested. In offering this explanation of the origin of the marble by metamorphism, it is proper to observe that we must not ascribe the whole of the change to its proximity to the line of anticlinal uplift of the Conshohocken axis. There is a tendency in the *whole* of the limestone of the Southern half of the general valley to a much greater degree of alteration than belongs to the same rocks in the Northern half. Throughout this entire synclinal belt the metamorphism from heat, of course, has been far greater along its Southern than upon its Northern margin, partly because the strata of the former side are nearer the principal injections of igneous rocks of the whole region, and partly in consequence of the perpendicular or even inverted position which has permitted the subterranean volcanic vapours to pervade them more freely, and exert their maximum influence.

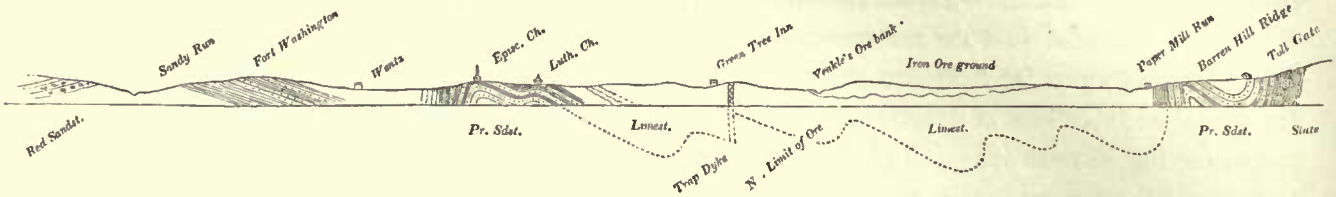
Analogous with this general tendency to a higher degree of metamorphism along this South side of the basin, we have the effect of the powerful anticlinal uplift of the Bethel Hill axis, causing a similar greater change along the narrow belt immediately adjoining it on the N., where the limestone is likewise in the condition of marble.

Third Anticlinal of Primal Rocks.—A short and relatively insignificant flexure of the strata ranges near the northern margin of the Limestone Valley, and throws up a ridge of the Primal rocks from a little N. of Frea's Corner, where it is encroached upon by the edge of the red sandstone, to the point S. of Reuben Cox's Limekilns. Near the Western end of this ridge the rocks composing it are well exposed in two or three small quarries; while a road leading a certain distance along its summit enables us to detect the Primal white sandstone capping the talcose slate quite near its crest. The Primal rocks are exposed in this ridge through a length of a little more than one mile. On its Northern flank the white sandstone appears to be inverted, or to dip Southward. Between the North base of the ridge and the next or fourth anticlinal, there runs a narrow trough of the Magnesian limestone, about one-third of a mile broad. This at its Western end is shut under by the overlapping edge of the red sandstone, which here crosses the limestone obliquely from near the Western end of this third to the Western point of the fourth anticlinal of Primal rocks. In this trough the limestone is quarried near the road leading N. from Frea's Corner, and again more extensively at the limekilns at Reuben Cox's.

Fourth Anticlinal of Primal Rocks.—A fourth and comparatively feeble anticlinal flexure lifts the Primal rocks to the surface through the limestone of the valley in the Church Ridge, crossing the Wissahickon Creek near the village of Whitemarsh. East of the Wissahickon this axis at the Bethlehem Turnpike exposes only the uppermost of the Primal rocks, or the white sandstone. On the south side of the anticlinal axis line, or fold, these strata dip at a moderate angle to the southward. On the North side they dip perpendicularly, making this a flexure of the true normal form. The Episcopal Church at Whitemarsh crowns the summit of this regular anticlinal ridge. In the exposure at the Turnpike, the altered sandstone is pervaded with cleavage-planes, dipping according to the prevailing law of cleavage-structure throughout all Southern Pennsylvania, at a rather high angle to the S. Near the very axis of the flexure the dip of the cleavage-joints is towards the axis plane, or steeply to the N., making, with the South-dipping cleavage of the beds N. of the axis, that *fan-like* arrangement of these fissures which is so characteristic of anticlinal folds in strata highly susceptible of cleavage-structure. (See the Section.)

To the Westward of the Wissahickon this anticlinal belt of the Primal rocks is prolonged into a ridge considerably higher and longer than that crossed by the Turnpike at the Church, extending for about three miles; it terminates in a low point near the extension of the Plymouth road. It is flanked, and is even saddled for much of its length, by the white Primal

FIG. 16.—Section along the Bethlehem Turnpike from Sandy Run to Chestnut Hill.



sandstone. The Primal slates, somewhat talcose, but in a less metamorphic condition than on the Southern side of the valley, emerge to the day in several places along the crest of the ridge. They are much affected, as usual, by cleavage; and though the anticlinal structure of this long narrow hill is obvious, no exposures permit us to detect the actual place of the turn of the dip westward of the turnpike at the Wissahickon.

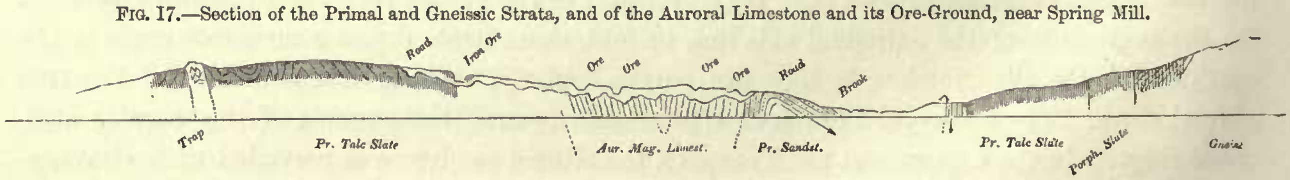
A trough of limestone—that, namely, in which Hains's Inn is situated—is embraced between this axis of the Church Hill and the Fort Washington Ridge, or northern general boundary of the valley; but though doubtless prolonged far to the westward of the Wissahickon, this rock soon vanishes from view, being buried under the margin of the Middle secondary red sandstone. That overlapping stratum extends obliquely across the trough from the Wissahickon opposite Fort Washington to the Northern base of the anticlinal ridge of the Primal rocks, meeting this about half a mile west of that stream, and there bringing the accessible limestone to a point.

PASSAGE FROM THE PRIMAL TO THE AURORAL STRATA AT SPRING MILL AND CONSHOHOCKEN, ON THE SOUTH SIDE OF THE LIMESTONE BASIN.

DESCRIPTION OF SECTION PAST SPRING MILL ACROSS THE SOUTHERN SIDE OF THE LIMESTONE BASIN OF MONTGOMERY, BEING A CONTINUATION OF THE SECTION ALONG THE SCHUYLKILL FROM PHILADELPHIA TO SPRING MILL.

The accompanying Section is intended to illustrate the relations of the Primal strata at the Schuylkill to the Gneissic rocks beneath them, and to the Auroral limestone overlying them.

FIG. 17.—Section of the Primal and Gneissic Strata, and of the Auroral Limestone and its Ore-Ground, near Spring Mill.



It commences on the point of the Furnace Hill, just east of the William Penn Furnace, at the northern or upper limit of the gneiss. Here the passage from the harder gneiss to the softer porphyroidal talcoid slates is marked by a decided change to a gentler slope on the flank of the hill. A portion only of the lower Primal rock is seen in the point of the hill as it stretches towards the Schuylkill. From the position of the outcrop of Primal sandstone at Lentz's old ore-digging, it may be inferred that the section crosses the same outcrop nearly at the road at the base of the hill. There is a blank of about 400 feet between this road and the base of the Barren Hill Ridge, but this blank occupied by the surface materials of the little valley is evidently underlaid by the Primal strata, no Auroral limestone having ever been detected here in wells or excavations. The section now crosses the ridge near a quarry of the upper beds of Primal white sandstone, which here dips to the S. at an angle of 35°. Just north of the crown of this narrow ridge, the same white rock has been recognised in sundry wells sunk in quest of ore, dipping perpendicularly, or even turned under to a S. dip of 85°, proving that the anticlinal axis of the ridge lies between these wells and the quarry before mentioned on its south slope.

In immediate contact with these perpendicularly-dipping beds of Primal sandstone occur steeply-inclined beds of dusky ferruginous magnesian limestone pervaded with cracks, giving the rock a brecciated aspect. At this junction of the Primal and Auroral strata is the southern limit of the deep deposits of ferruginous clay and loam which imbed the large accumulations of brown hæmatitic iron-ore, which constitutes already such a prominent source of wealth to the whole southern half of this great limestone belt. Our section crosses about 50 feet of recognisable outcrop of the Auroral limestone, seen sometimes in the deeper ore-diggings, sometimes in the valley of Spring Mill Brook. Wherever exposed, these limestone beds dip a little to the south of the perpendicular. Beyond the limit here stated no rock is exposed for about 400 feet, until we approach the road leading from Spring Mill to Marble Hall; but in that vicinity we detect steeply-dipping talcoid slates, elevated by the anticlinal axis further north. Our section now crosses the talcoid Primal slates on the south side of this anticlinal for about 600 feet. These slates dip like the limestone at a very steep angle to the south. Here on the northern side of the summit of this ridge, which is the prolongation of Bethel Hill of Conshohocken, our section encounters the large trap-dyke which extends from the south slope of Bethel Hill through the village of Conshohocken and the crest of this slate ridge past the point we are upon to the Perkiomen Turnpike, which it crosses between Marble Hall and Barren Hill. This dyke is here about 30 feet in width. Northward from the trap-dyke we pass over in the line of section between 500 and 600 feet more of talcoid slates, till we approach the northern foot of the hill, where we detect the lower upturned beds of the Magnesian limestone. At the base of the hill we come upon the blue and shaded marble; and here the marble belt is between one-third and one-half of a mile broad.

Our section displays a wide trough or deposit of ore-ground between the two anticlinal uplifts which it intersects. This ore-ground beginning on the south just north of the summit of the White Sandstone Ridge, reaches to the foot of the higher ridge of Primal talcoid slate. Neither on the White Sandstone Ridge nor the Talcoid Slate Hill is there any depth of ferruginous soil sufficient to include a notable amount of iron ore; but in the trough between them, the ore, containing loam and clay, rests in a very deep deposit, measuring in some longitudinal gutters not less probably than 100 feet. It is in these deeper collections of the ferruginous earth that the largest deposits of the richest ore should be obtained. The iron contained in this ore-bearing soil has been in part derived from the lower beds of the Magnesian limestone, some of the strata of which are excessively ferruginous; but in larger part it has proceeded, no doubt, from the disintegrated talcose slate, a rock abounding in iron, as the red colour and composition of its clays demonstrate.

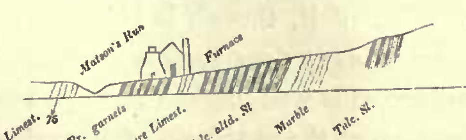
The line of our section crosses another narrower belt of ore at the foot of the Furnace Hills. This deposit pertains to a deep lodgment of ferruginous earth and decomposing slate-rock, just at the contact of the talcoid slates and the Primal White Sandstone. The ore is for the most part more sandy than that which overlies the limestone and talcoid slates further removed from the Primal white sandstone.

PASSAGE BEDS AT THE MOUTH OF MATSAN'S RUN OPPOSITE CONSHOHOCKEN.

A transverse section at Caldwell's Furnace, from the Primal Slates into the Auroral Limestone, displays,—

1. Talc-slate on the north slope of the bounding ridge, dipping perpendicularly.
2. North of the slate, a narrow band of mottled blue-and-white crystalline limestone and marble.
3. A bed of talcoid or nacreous altered slate, apparently about 100 feet thick.
4. A band of impure altered limestone, about 50 feet thick. This passes under the southern edge of the Engine House.

Fig. 18.—Section at Caldwell's Furnace.



5. A talcoid and garnetiferous altered slate, extending to within 100 feet of the brook. This underlies the Furnace.
6. The lower beds of the Auroral magnesian limestone, as a continuous mass, visible on both sides of Matsan's Run and in its channel.

On the north side of Matsan's Run, or about 200 feet south of the Conshohocken bridge, there is a good exposure of the lower beds of the Auroral magnesian limestone near the railroad; here the rock is sub-crystalline, and mottled whitish and blue; it weathers of a ferruginous yellow, and dips without contortion 77° to N. 25° W.

The alternating or passage beds, above described, range westward up the valley of Matsan's Run, on its south side nearly to its head, some of the limestone bands having been quarried to furnish a flux for the Furnace.

THE PRIMAL WHITE SANDSTONE BOUNDING THE CHESTER COUNTY VALLEY WEST OF THE SCHUYLKILL.

Having defined the outcrops of the Primal white sandstone bordering the main basin of limestone of Montgomery County, and traced them to their terminations E. of Willow Grove, and having shown the several narrow anticlinal belts in which they appear within this basin, we will now follow them along both margins of the same great trough, as it stretches in a nearly straight line through Chester into Lancaster County.

THE SOUTHERN OUTCROP OF THE PRIMAL SANDSTONE.

It is an interesting fact disclosed in the attempt to trace continuously the Primal white sandstone along the Southern side of the Chester County Valley, that it ceases almost entirely on this border of the basin in the neighbourhood of Spring Mill, or E. of the Schuylkill, and that no effort to discover it in a regular outcrop of any length or appreciable thickness has yet disclosed it on the West side of the river, or even for several miles westward, until we reach points opposite the Spread Eagle and the Paoli. North of the latter place the outcrop of this sandstone may be recognised at two or three spots just at the base of the South Valley Hill; in some instances by the character of the soil, and the angular fragments of the sandstone imbedded in it; and in one case in a house-well at the country-seat of Mr Thomas Biddle. In these spots the thickness of the whole stratum cannot exceed a very few feet, nor can we suppose it continuous; for if it were, we should almost certainly detect it in the numerous lanes, and in the railroad cuts, which so abundantly intersect this border of the basin.

The next point further westward at which we recognise unequivocally the outcrop of this interesting rock is on the South Road, about one and a half miles E. of Downingtown, or one-third of a mile W. of the Railroad Viaduct. Here the rock is exposed in the gutter of the road, and it has been dug into in a well near by. A soft sandy material, the decomposed stratum, is yet distinctly discernible at the spot. It presents its ordinary, somewhat talcose, aspect. The dip of the strata, both here and generally along this margin of the valley, is very nearly vertical. We cannot discover any vestiges of the formation, either S. of Downingtown or for a few miles W.S.W. of it, though it is very probable that it appears and disappears in the same obscure manner as it does further eastward; but in the vicinity of Coatesville, and westward of that village, this well-marked rock possesses a sufficient thickness to project conspicuously in rugged outcrop at the entrances of the numerous ravines and gorges which there cut the South boundary of the valley. Even there, however, it seems not to possess a thickness of more than 30 or 40 feet, and is sometimes thinner; and yet, from the superior hardness of its semi-vitreous mass, and its silicious nature making it invulnerable to the chemical influences of the elements, it is a very prominent feature in the stratification, even where thus thinly developed. The rock in nearly perpendicular dip thus holds its course to the westward, skirting the border of the valley until the limestone itself terminates, and the two sides of the basin ultimately unite. This union of the two lines of the Primal sandstone occurs near the Conewango Creek in Drumore Township; yet the long and remarkably straight synclinal trough within which they lie stretches on in precisely the same course for a few miles towards M^cCall's Ferry; but before reaching the Susquehanna River the synclinal structure ceases, and a monoclinal South dip alone remains. Only the lower Primal rocks, or the micaceous crystalline slates, reach the river. Indeed, it is doubtful if the sandstone extends even to the Conewango.

In another Chapter it is shown that other outcrops of the Primal white sandstone occur some miles to the S. of this long line, and entirely insulated from it, proving that the formation has at one time spread itself very extensively to the southward.

BELTS AND LOCALITIES OF SERPENTINE SOUTH OF THE LIMESTONE VALLEY OF MONTGOMERY AND CHESTER COUNTIES.

1. *The Serpentine and Steatite Range of the Schuylkill in the Southern Edge of Montgomery County.*—This, the most eastern zone of the magnesian rocks in Southern Pennsylvania, lies entirely within the middle or micaceous belt of gneiss, or highly metamorphic Azoic rocks, but near its northern border. It is a long and straight line of outcrop of steatite or serpentine, extending from the northern brow of Chestnut Hill between the two turnpikes, across the Wissahickon Creek and the Schuylkill to near the Baptist Meeting-house Road, about a mile west of Merion Square. Along the eastern and central parts of its course, the southern side of this belt consists chiefly of a talcose steatite. The northern side, containing much serpentine in lumps, dispersed through the steatite; but towards the western side this separation seems to disappear. The serpentine division, or band, is conspicuous on the line leading from Chestnut Hill down to Thorpe's Mill, where enormous blocks, without any distinct traces of stratification, cover the surface along the line of the bed or dyke. The same rock is similarly exposed on the west side of the Wissahickon, opposite Thorpe's Mill, and thence westward along the north side of a lane leading up to the Ridge Road. The whole belt is vaguely exhibited at the summit-level of the land between the Wissahickon and Schuylkill valleys; but, descending towards the Schuylkill, we again discern, on the north side of the line of outcrop, the huge blocks of mingled serpentine and steatite, until, near the Schuylkill river, they choke the bed of the ravine next north of the Soap-stone Quarry. On the west side of the Schuylkill, this serpentine and steatite rock is still visible in large blocks, a little above the soapstone of that bank of the river; but between this point and the vicinity of Merion Square, the rock, though discernible at a few points, is nowhere conspicuous. About one-third of a mile west of Merion Square, it is quite prominent again, the surface being strewn with huge masses. It may be distinguished at once from any other mineral aggregate of the region, not merely by the enormous dimensions of its loose blocks, but by its rugged, frowning, dark aspect, and also by the general coating of dark lichens and other cryptogamous plants. The serpentine seems not to follow the steatite the whole distance to the western termination of the belt.

Only in a few neighbourhoods does the steatite, constituting generally, as already said, the southern half of the tract, present itself in sufficient purity and mass to be profitably quarried. On the east bank of the Schuylkill, however, about two miles below Spring Mill, at the spot called the Soapstone Quarry, it has long been successfully wrought; and on the west side of the river, in one place on the bank, and at another about one-third of a mile west, the rock has been quarried, though upon a less extensive scale. In former years it was excavated to a small extent on the west bank of the Wissahickon, just opposite Thorpe's Mill; but the band of steatite at this place appears to be too thin to warrant its being pursued at present.

Both at the Wissahickon and the Schuylkill, the steatite, which is regularly stratified, dips steeply to the N. 35° W., agreeing in its inclination with the subjacent beds of mica-slate; but on the west side of the Schuylkill, at the points where it has been exposed in quarries, it dips at a more moderate angle to the south-east, thus indicating a probably synclinal structure in this central portion of the belt. The material is used chiefly for the lining of stoves, fire-places, and furnaces. The principal market for it is the city of Philadelphia.

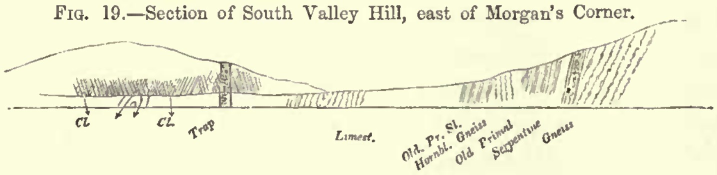
Towards the end of the last century and the beginning of this, before the introduction of the marble of Montgomery

County for street-door steps in Philadelphia, this easily-dressed stone was in some demand for that use; but it proved badly adapted to the purpose, because of the very unequal hardness of its different constituent parts, there being a difficulty in getting blocks free from knotty lumps of imperfectly-crystallised serpentine, which make it to wear unevenly under the attrition of the feet. We may sometimes see, in an old and much-worn door-sill of this rock, these knots of the serpentine mineral projecting above the steatite like hob-nails in a plank.

2. *Second Outcrop of Serpentine in our progress westward.*—The next outcrop of the serpentine in our progress westward, occurs on the western brow of the table-land of Gneiss just south of the narrow limestone trough of the upper part of Gulf Creek. It is within half a mile of Morgan's Corner. The exposure there has a length of only a few hundred feet, but it is at least 300 feet wide. It is bounded on the south by genuine gneiss, and immediately on its north by talcose and steatite slate. Between this belt and the narrow strip of limestone in the valley north of it, there is an uplift of hornblendic gneiss, distant from the serpentine about 100 yards. Immediately north of this last outcrop of the gneiss we encounter a repetition of the talcose-slate formation, or older Primal rocks under that highly altered gneissoid aspect which they wear so conspicuously on the Schuylkill between the Aramink and Spring Mill.

The belt of serpentine comprises both true injected or *igneous serpentine,* and *serpentinous steatitic talc-slate.* In the two quarries in which it is best exposed, stratification is visible in some places, but in others there is none. In a quarry east of the road, the dip is steeply northward, while in that on the opposite side of the road it is 70° southward.

FIG. 19.—Section of South Valley Hill, east of Morgan's Corner.



3. *Third Belt of Serpentine, or that of the neighbourhood of the Paoli.*—We come next in order to the most extensive serpentine range of Chester County. This has its eastern extremity on the farm of General Wayne, of Revolutionary memory, about one mile south-east of the Paoli Hotel, and just at the line of East Town and Willistown. Its western termination is near the western line of East Goshen, and about two and a half miles N.N.E. of West Chester. These limits give a total length of about six miles. Its course is W. about 25° S., coincident nearly with that of the strike of the gneiss and talcose slate which border it for the greater part of its length. Commencing in a narrow point of the General Wayne farm, it widens rapidly as we trace it westward, until, at a distance of a mile at and beyond Maris's Grist Mill, its total breadth is nearly 2000 feet. In this central part of its course it runs for nearly three miles almost parallel with the old State Road to West Chester, at an average distance of one-third of a mile, gradually approaching the road until it crosses it about four miles from the Paoli, or three-fourths of a mile north-east of East Goshen Friends' Meeting-house. It is here reduced to a breadth of no more than 400 or 500 feet. Under this average width it ranges on, passing the Barren Hill School-house and across Ridley Creek, and thence for one mile further to its termination beyond the old blacksmith's shop at John Gheen's farm. Throughout its entire range, this serpentine appears chiefly as a stratified rock, and in its widest central portion we may distinctly perceive that it has a synclinal or undulated structure. It is, indeed, rather an impure talcose slate, largely impregnated with serpentinous matter, than a zone of genuine intrusive serpentine. Dykes of this mineral it does, however, embrace, and these on a small scale are very numerous, but they bear in the aggregate a small proportion to the whole belt. Its stratified structure is well exposed at the crossing of the State road, where it dips 70° N.; also in the ravines which cut it near the Barren Hill School-house, and still more convincingly near the old smithy at John Gheen's, in which latter locality it has a nearly perpendicular dip, but discloses under close inspection innumerable minute contortions and plications of the thin laminæ of the rock.

The eastern end of this zone of serpentine is bordered both south and north by the talcose-slate formation, in which it seems to lie as a folded synclinal trough; but from the vicinity of Maris's Grist Mill to its western termination, its southern margin is in contact with a massive hornblendic gneiss, its northern touching in some places upon ordinary talcose slate, but in others, especially towards the western end, upon quartzose and garnetiferous micaceous gneissoid rock, of the group I have called Azoic. This garnetiferous micaceous gneiss may be seen dipping steeply northward, conformably with it, close to John Gheen's dwelling. The prevailing dip of the hornblende gneiss, bounding it on the south is northward 70° — 80°.

Along the northern edge, or a little outside of the northern margin of this line of serpentine, trap-rock occurs in greater or less abundance, and apparently as a succession of narrow elongated dykes. These seem not to be strictly parallel with the serpentine and other strata, but to observe a more North-east and South-west direction. Narrow dykes of this rock intersect, indeed, this range of Serpentine Barrens in many neighbourhoods, and this is a feature which may be noticed in nearly all the outcrops of serpentine within the State.

The crystalline minerals of this tract, few in number, will be mentioned in a future Chapter in connection with those of the other serpentine belts.

4. *Fourth Tract of Serpentine.*—There is a small and apparently insulated development of serpentine about three-fourths of a mile S., 45° W., from the old smithy near Gheen's dwelling. It is evidently not in the prolongation of the long belt just described, but is almost exactly in the range of the Serpentine Barrens, one mile north of West Chester, with which it is possibly united, though no external indications of such connection present themselves, there being an interval of half a mile between the small patch and the eastern extremity of the Main West Chester Line of Barrens. Though small, this area of serpentine is readily discerned, forming a little elliptical mound.

5. *Fifth Serpentine Tract, or that of the West Chester Barrens.*—In the same general line with the long range of serpentine traversing Willistown and East Goshen, though strictly about one-third of a mile further S.E. than its line of strike, is the Serpentine belt of the West Chester Barrens. The N.E. point of this appears to be just S.W. of the East Branch of Chester Creek, or one-fourth of a mile N.E. of the West Chester Railroad. It crosses the railroad nearly two miles from the centre of West Chester, exposing imperfectly its stratified structure in the railroad cuts; whence it ranges about one mile further between the forks of Taylor's Run. The mean width of this belt is at least 1000 feet. Though chiefly an impure and stratified serpentinous talcose slate, the tract includes many injections of genuine igneous serpentine.

Like all the middle and western portions of the Paoli belt, this tract is bordered on the South by massive hornblendic gneiss, while it is fringed on the North by the earlier talcose slate and micaceous slate of the South Valley Hill, into which it appears somewhat abruptly to graduate.

The more compact varieties of this serpentine have been used for building-stone in West Chester and its vicinity, and the material proved to be well adapted for many architectural uses. It has a very pleasing effect when newly built into walls, as it has a quiet tone of greyish green; but exposure to the elements for a few seasons causes it to fade, or to become more dull and greyish. Several neat structures have been built of it.

The chief minerals of this range hitherto discovered are mentioned in the general list already referred to.

6. *Sixth Serpentine Outcrop.*—To the S.W. of the Main West Chester Belt of serpentine, there occurs near Hoope's Saw Mill a small outcrop of serpentine and steatite, which is evidently in the same line of strike with the large serpentine tract north of West Chester, and the small detached one to the east of that.

7. *Seventh Outcrop.*—Another trivial exposure of Magnesian rock, chiefly steatite, occurs on Taylor's Run, on the land of Caleb Cob, close to an outcrop of granular limestone. These are about half a mile S.W. of the previously-mentioned locality of serpentine.

8. A still more trivial locality of steatite is at the Black Horse Tavern, on the road to Taylor's Ford. It is in the same general line with the three previously-mentioned localities of magnesian rocks.

9. Again, on the same line, both serpentine and steatite present themselves about three-fourths of a mile S.W. of the Brandywine, on the farm of Mr Wurth.

All the above six exposures of serpentine and steatite occur so nearly in one line, and this is so probably a line of dislocation connected with the synclinal fold of the older strata, that we can hardly doubt that these outcrops derive their existence from one chain of injections of true serpentine mineral along the southern margin of the talcose Primal slates.

10. An entirely insulated exposure of associated steatite and serpentine occurs near Marshall's Mill, on the West Branch of the Brandywine, on the farm of Humphreys Marshall. This does not seem to be connected with any of the other serpentine injections of the district, for it is too far South to be in line with the six outcrops previously described, and too far North to be related to the large serpentine ridge east of Unionville. It is more strictly in bearing with a small exposure of the same rock, which occurs in the neighbourhood of West Marlborough Inn.

11. The last-mentioned locality, West Marlborough Inn, possesses a small exposure of stratified serpentinous rock, containing injections of serpentine; and this is the most Western of all the outbursts of this rock until we come to the great one, which commences at the Little Elk Creek and extends for many miles to the Susquehanna River, which it crosses.

12. There succeeds now a more Southern line of insulated exposures of serpentine, the most Eastern of which is encountered half a mile S.E. of the Willistown Inn, in Willistown Township. This includes both serpentine and steatite.

13. The next locality of the serpentine rock of this belt is near Darlington's Corner, and here occur carbonate of magnesia and crystalline chlorite, besides the interesting mica mineral Klinoclore.

14. Near Strode's Mill, in East Bradford Township, there occurs a large outburst of serpentine, with lithomarge and fine talc connected with it.

15. Another exposure of the same magnesian rock exhibits itself N.W. of Strode's Mill, near the Prospect Hill Academy. This is nearly in a line with a large belt of the same rock east of Unionville.

16. One or two detached knolls of serpentine occur in Lower Oxford Township, the furthest west of the small insulated patches known to us.

17. *Serpentine Belt of the Unionville Barrens in Newlin Township.*—We have arrived now in our progress towards the S.W. at a conspicuous belt of serpentine, about equal in magnitude to that north of West Chester, and one of the most interesting of the whole series for the crystalline minerals which it contains. It lies in the south-eastern corner of Newlin Township, about one mile N.N.E. of the village of Unionville. It has a mean breadth of some 800 feet or more, and its total length is about one mile. It lies altogether within the micaceous talcose slate, many portions of which rock wear here a very quartzose and sandy aspect. This belt consists of stratified serpentinous talcose slates, with much injected or infused true igneous serpentine. It is intersected by several narrow dykes of fine-grained basaltic trap, which trend N.E. and S.W. Besides these, there occur some interesting mineral veins. One of these, which has attracted the notice of mineralogists, is a narrow veiu of very hard white albite, including many crystals of corundum, some portions of the vein being indeed almost an emery or corundum rock. An attempt was made some years ago by a skilful and most zealous mineralogist of Chester County, D. Lewis Williams, to mine regularly this very hard and intractable but valuable material; but the undertaking was not long persevered in. Loose chunks or blocks of the corundum rock strewing in one place the north slope of the ridge of serpentiue, derived either from the above-mentioned vein or from other injections, were collected at one time to the amount, it is said, of between six and seven tons, and exported to Europe.

Besides the albite with corundum, there occur several veins or dykes of granite, consisting almost exclusively of felspar. This mineral is here in such purity, indeed, as to be in much request for the purposes of dentistry. Owing to the demand for felspar entirely free from extraneous associations, a successful quarry has been opened, and has already furnished a considerable quantity for the market. Associated with the pure orthoclase, which is in very large crystals, there is also occasionally much oligoclase or soda spodumene, another felspar mineral.

There are several other insulated small localities of serpentine west of the Brandywine, but they are not of sufficient importance to be entitled to a special description.

Long Serpentine Belt of the State Line on the Southern Edge of Chester and Lancaster Counties.—A very extensive belt of stratified and injected serpentine rocks ranges near the State Line from the Little Elk Creek in Chester County across the Octorara Creek to Maryland, and thence across the Susquehanna. Its length from the Little Elk to the Susquehanna exceeds 17 miles, and the tract is prolonged beyond the river through the northern edge of Maryland for several miles further. Its mean width may be given at about one mile. This is a range of wild and stony barrens scarcely tilled, except in a few spots on its two margins, and overgrown with stunted black oaks, and other trees characteristic of the magnesian soils of all these serpentine belts. Along its southern border this magnesian formation is in contact with black hornblendic gneiss, but apparently without conformity of dip. On the Susquehauna a different rock, a micaceous talcose slate, bounds it on the S.; along it northern edge it is everywhere bordered by the micaceous talcose slate of the Primal series; and this latter formation seems to lap round its eastern extremity, near the valley of Little Elk River. Much trap-rock presents itself just west of the Little Elk along the southern edge of this range of serpentine, and dykes of that material occur within and adjacent to the belt, especially throughout its southern half, and apparently along its whole course. One of these may be seen on the main road leading to Carter's Ferry at the crossing of Buck Run.

The zone of serpentine rocks now before us is especially remarkable for containing large quantities of chromiferous irou-ore. It is indeed one of the chief sources of chromate of iron in the United States, having already furnished large supplies of this mineral for both the home and the European demand. The chrome ore penetrating the serpentine rocks in true lodes or veins, with more or less regularity, has likewise been met with in great abundance in a fragmentary state upon the surface of the barrens, and to a small depth amid the disintegrated materials of the serpentine. It has, therefore, been mined both by regular mine-shafts, and by superficial pits or holes, and trenches. The scattered surface ore, locally called "Sand Chrome," has been extensively gathered from the beds of the ravines and valleys which intersect the barrens, and after being washed on the spot has been shipped away to market. When, for a succession of years after the first development of this mineral, the high price of $45 per ton stimulated the discovery and preparation of it, many thousand tons of the stream or "sand chrome" were transported to the sea-board, especially to Baltimore. More lately, since the richer deposits of the more accessible surface ore have been in chief part exhausted, resort has been had to mining in some of the more regular solid veins. Only two such subterranean excavations are now, however, systematically prosecuted, owing partly to the circumstance, that the present market for the mineral is easily glutted, and partly to the fact, that nearly all the most promising localities of the region are at present monopolised by one individual. Both of these mines are situated a little westward of the East Branch of the Octorara Creek. It will suffice to present here the chief features of one of them, namely, Wood's Chrome Mine. This is situated not far from the Horse-shoe Ford of the Octorara, the vein of chromiferous iron-ore observing a nearly N.E. and S.W. direction, and dipping 45° to N.W., or with the local slope of the ground. It has been mined throughout a length of about 300 feet. As a lode it is quite irregular, varying from a width of 20 feet to nothing, or expanding into large pockets of ore, and then contracting until the walls meet. It also throws off several branches, some of which return into the main vein. The shaft at present (1854) has a depth of about 150 feet, and an open drain meets the shaft about 20 feet below its mouth.

This mine produces at present between seven and eight tons of excellent chrome ore daily, the fruits of the labour of three hammers and the attendant aid. The present price of the chrome ore is about $25 per ton. The gross yield of this mine is therefore nearly $200 per day. The finer pieces of the ore are packed in barrels on the spot as they come out of the mine, and are thus sent to Europe without re-handling. The rest of the ore, after dressing and washing, is transported to Baltimore and other home markets.

The Line Mine.—The other chief mine situated immediately on the boundary line of Pennsylvania and Maryland, and called therefrom "The State Line Mine," is not now actively wrought. Its shaft is about as deep as that of Wood's Mine. The aggregate former yield of the Line Mine amounted to several thousand tons.

There are several interesting minerals associated with the chromiferous iron-ores and serpentine of this range of magnesian barrens, and nearly all the species occur equally at the two mines here spoken of. These minerals are enumerated in the general chapter on the mineral localities of the Primal district of the Atlantic Slope of Pennsylvania.

There is another shorter tract of serpentine barrens containing both the stratified and the unstratified intrusive varieties of the rock, situated about two miles north of the State Line in Lancaster County on the waters of the Conewango. The southern edge of this is near the little village of New Texas. The whole belt is about three miles long, and more than half a mile wide, and it has somewhat the form of a crescent, its convex curve being to the N.W. Its north-east end is about one and a half miles E. of the Conewango Creek, which it crosses about two miles N. of the State Line, extending westward of the stream about a mile until its south-west extremity is within two miles of the Susquehanna, and a mile and a half N. of the State boundary. From this locality much silicate of magnesia has been taken, and transported to the chemical works of Baltimore and elsewhere, for the manufacture of Epsom salts and other preparations of magnesia. The excavation of this mineral is no longer pursued; it was dug only in superficial pits.

Titaniferous Iron Ores.—There are in the main serpentine belt of Lancaster four or five localities of titaniferous iron-ore, commencing near the Horse-shoe Bend of the Octorara, and ending about three miles E. of the Susquehanna River. At one of these, on the farm of Mr Jenkins, some of this ore has been mined, but only to a trivial extent. A small amount of the same refractory variety of iron ore has been also dug on the shorter tract of serpentine barrens N. of New Texas. A more productive locality occurs near the Baptist Meeting-house, where several hundred tons of the variety called Bird-eye Iron Ore have been successfully mined.

A careful examination of these two belts of serpentine near the State Line of Lancaster County cannot fail to convince any observant geologist that the material, ordinarily termed serpentine, as presented in these barrens, comprehends both a stratified and an unstratified rock. Pure serpentine is here found only in the form of dykes intruded through a stratified serpentinous talcose rock, evidently a metamorphic clay-slate—the mica and talc-slate formation of the Susquehanna. The stratified serpentinous rock seems to have been impregnated with the magnesian minerals during the intrusion of these veins of igneous serpentine. The evidences in support of this view are abundant in the ravines which intersect the barrens north of the village of New Texas. The genuine serpentine rock is itself a material of quite diversified aspect, some of it being of a dark-green colour, and very tough; other varieties less dense and heavy, and much more easily fractured, and of a pale or yellowish green. This latter kind usually abounds in contact with the chromiferous iron-ore at Wood's Mine and the other chrome localities. Certain small patches of the rock wear a slightly pinkish colour, but the predominant hue is some variety of green.

The strata crossed successively in proceeding northward from the southern side of the more southern or main zone of serpentine near the Susquehanna, is as follows:—

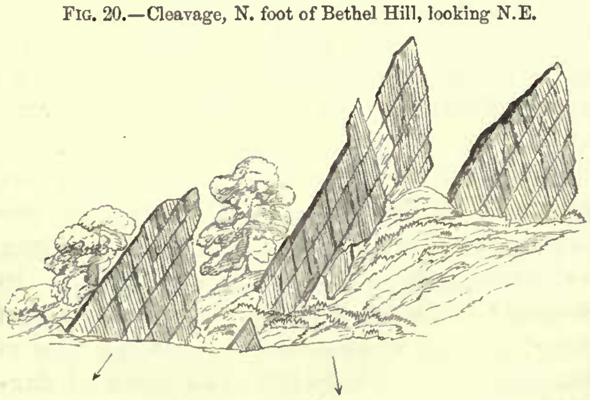
1. Hornblende gneiss and trap-rocks.
2. Serpentinous talcose slates, with dykes of serpentine.
3. Gneissoid, micaceous, and talcose slates, yielding a ferruginous soil, containing bands of whetstone or mica-slate.
4. Serpentinous stratified talcose sedimentary rocks, full of intrusive serpentine.
5. An alternation of talcose, micaceous, and argillaceous slates, embracing the roofing-slate of the Peach Bottom Range.

This latter group belongs to the older Primal slates, which extend all the distance to the Limestone Valley under various remarkable conditions of metamorphism, some of them even simulating the ancient Gneissic rocks.

At the State Line, five miles W. of the Susquehanna River, we find a small ridge of serpentine. It is about a mile long, and lies principally in Maryland. In this belt the mineralogist may obtain fine specimens of green serpentine, actinolite, chlorite, and asbestos, tintaniferous iron-ore and magnetic iron-ore. A band of chlorite slate, near the northern base of the ridge, contains, in abundance, beautiful octahedral crystals of the last-named mineral. About one mile northward is another smaller ridge of serpentine, like the serpentine belts of Chester and Lancaster counties; that above described occurs in a lenticular form in the talcose and chlorite slates.

The following cut is introduced in illustration of a remarkable feature connected with the cleavage of the Primal slates described in this Chapter. It exhibits an instance of the segregation of talc and quartz, in thin lenticular laminæ, in planes coincident with the planes of cleavage, and obliquely transverse to the bedding of the rock. It is interesting as proving crystallisation to be the result of the same metamorphic influence, only more energetically exerted, which has caused the cleavage. The locality whence the drawing was taken, is at the N. foot of Bethel Hill. The strata dip steeply N. from the anticlinal axis of the Hill; the cleavage obeys the usual law, and dips steeply S., and approximately parallel to the axis plane of the flexure, on the flank of which it occurs.

Fig. 20.—Cleavage, N. foot of Bethel Hill, looking N.E.



CHAPTER II.

THE PRIMAL SERIES BOUNDING THE MIDDLE GNEISSIC DISTRICT.

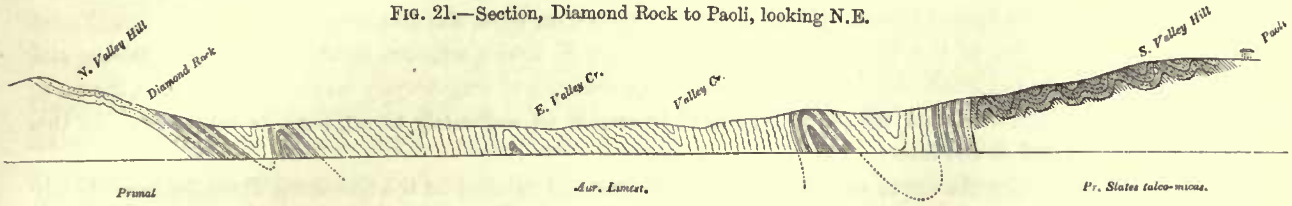
We may now trace the Primal white sandstone and slate as we find them developed N. of the Chester County Limestone Basin, and S. of the edge of the red sandstone. In doing this we shall have occasion to follow, first, the conspicuous and continuous zone, bordering the Chester County Limestone Valley on the N., under the name of the North Valley Hill; in the second place, the Mine Ridge and its spurs, all of which are formed of this rock; and in the third place, the Welsh Mountain and its dependencies.

PRIMAL SERIES, WHITE SANDSTONE AND SLATES IN THE NORTH VALLEY HILL.

Commencing W. of the Schuylkill about one mile E. of Valley Forge, the Primal white sandstone of the North Valley Hill, so called, emerges into view from beneath the overlapping margin of the Middle Secondary red sandstone at the Eastern point of the hill known as Mount Sorrow, or that upon which Washington and his forces were encamped, amid great sufferings and privations, in the memorable winter of 1777-8. Here the Primal rocks, consisting chiefly of the older semi-crystalline slates, cross the East Valley Creek in a broad contorted belt, not less than half a mile in width. As we trace the formation westward, it would seem to expand rapidly, and to embrace a much larger portion of the white sandstone, and a less relative amount of the underlying Primal slate group. This change seems to take place in that section of the ridge which is called Mount Joy, for when we reach the Western point of Tredyffrin Township, or the vicinity of Ayer's Store, the chief rock visible is the white sandstone; indeed, this is the case in the vicinity of Diamond Rock, though the north flank of the ridge at this latter point includes also a considerable thickness of Older Primal talcose slate. Throughout this part of its length, the belt of the Primal rocks is disturbed in dip by two or three closely-folded undulations, and it is in consequence of these that the sandstone at the Diamond Rock is spread over the Southern slope and summit of the ridge in so broad an outcrop. The lesser contortions and fractures connected with these undulations are the evident causes of the numerous veins and cavities, filled with crystals of quartz, which occur in the compressed and fractured masses of the sandstone at Diamond Rock, and which have conferred upon this cliff its name. A partial interruption in the continuity of the North Valley Ridge occurs at the depression above Ayer's Store, and it would seem that the outcrop of the Primal rocks takes here a sudden offset northward, the result, apparently, of the cessation of the undulations prolonged thus far from the Eastern end of the ridge, and the introduction of one or more new anticlinal waves in the strata extending from this point westward. It is pretty obvious that near Ayer's Store, almost the whole of the broad outcrop of the Primal rocks has been swept from off the gneiss, and only a single monoclinal line of the sandstone left at the base of the hill in contact with the limestone of the valley. From this jog or local change in its course, the Primal belt ranges with remarkable straightness towards the W.S.W., and with no actual interruption, until in Lancaster County it coalesces with the range bounding the Limestone Valley on the S. It presents, however, several decided fluctuations in its breadth, due to changes in the dip, and especially to the introduction of a less or greater number of narrow anticlinal undulations in it. The structure of this zone is pretty well exposed in all the principal gorges through which the tributaries of the Brandywine and the Octorara drain through it in their progress southward. In these natural sections, though the edges of the strata are generally much obscured by fragmentary rubbish and soil, it is easy to detect the presence of usually two, and sometimes even three, closely-folded anticlinal plications, the dip being generally at a high angle to the S.E. From the changes which arise in these flexures, the breadth of the whole belt varies from a quarter of a mile in some places to at least three-quarters in others. In sundry cases we may detect sharp saddles, or anticlinal uplifts of the subjacent gneiss rocks, subdividing the whole belt, at least at the level of the beds of these transverse valleys, into a succession of parallel, closely-folded, synclinal troughs. In some instances the lower strata of the Primal series, thus brought up on the back of the gneiss, is so crystalline and gneissoid from metamorphic action, especially where it is contiguous to dykes of intrusive granite, that to determine always the boundary which separates the two sets of rocks is by no means easy.

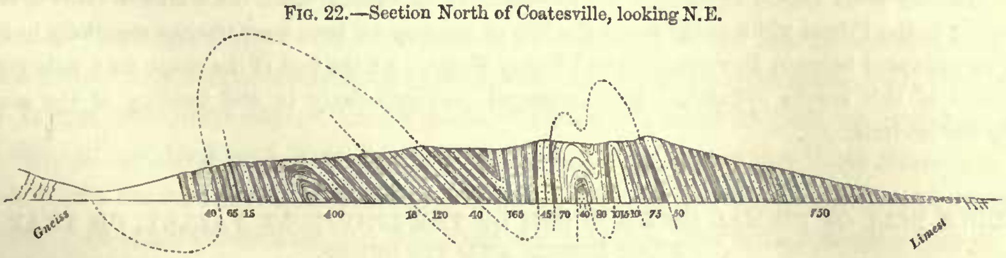
For several miles E. of the East Branch of the Brandywine, there seems to be but an insignificant thickness of Primal talcose slate associated with the white Primal sandstone ; but approaching the West Branch of that stream, or the vicinity of Coatesville, both the upper and lower Primal slates appear in the series in rapidly and steadily augmenting force. There is no feature connected with the Primal rocks of this district of Pennsylvania so remarkable as their appearance and disappearance within the narrow limits of a few miles. This fluctuation is perhaps most conspicuously exhibited in the striking contrast presented in the composition of the North and the South Valley Hills between Valley Forge and Downingtown, in which district it has been already shown that there is on the South side of the limestone even a total absence of the white Primal sandstone, or a bed of it so thin as generally to escape detection ; while on the North side of the valley the formation is developed under a thickness of at least 50 feet at Diamond Rock and elsewhere. Again, to the S. of the basin there appears to be a vast expansion of the lower Primal slates in their metamorphosed condition of talco-micaceous slates ; but to the N. of this great trough, at a distance no greater than two or three miles, there is a great deficiency of this schistose group. (See Fig. 25, Section through Coatesville to mouth of Buck Run, at the end of this Chapter.) It would seem that both the sandstone and the argillaceous or slaty members of the series had in this part of their original area been thrown down in irregular patches, and in beds of quite inconstant thickness. When we reach the West Branch of the Brandywine, and examine the constitution of the Primal series there, or study it in sections still further W., we are struck with a marked difference of type compared with that which it possesses at or E. of Downingtown. Near the latter place, at the pass of the Brandywine, through the North Valley Hill, the Primal slate is almost wanting ; and the white sandstone, folded in several successive waves, seems at first, until these are recognised, and their influence estimated in multiplying the thickness of the belt, to be a formation of enormous depth, whereas it nowhere in reality surpasses 100 feet. The first outcrop of the rock, or that which bounds the valley, presents the sandstone in its usual indurated or slightly vitreous condition, and in this characteristic state it contains in the thin partings separating its remarkably parallel layers, delicate coatings of pure white talc; while imbedded in the surfaces of the sandstone are numerous very small needle-shaped crystals of black schorl, always more or less broken, as if from a difference in the law of shrinkage, or cooling of the rock and the mineral. The other outcrops or folds of the stratum which lie further N., and nearer to the border of the gneiss, and which are more injected with igneous granite, show a still more advanced stage of metamorphism. There the rock consists of an excess of granular quartz, involving specks of crystalline felspar, the presence of which, and of the included talc, renders it sometimes difficult to distinguish the altered stratum from some fine-grained white granites. The schorl is, however, a sure guide to the recognition of the sandstone, however altered.

Fig. 21.—Section, Diamond Rock to Paoli, looking N.E.



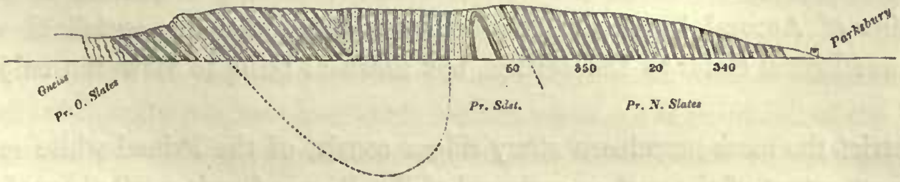
An inspection of the Sections across the Chester County Valley and its north and south bounding hills, one extending from Phœnixville to the Paoli, another along the East Branch of Brandywine through Downingtown, and the third through Coatesville by the West Branch, will serve to show the relative development of the different members of the Primal series in these different districts, and by comparison, exhibit those remarkable fluctuations in their dimensions to which we have alluded. This comparison will show that, while in the two Eastern sections very little Primal talc-slate occurs on the North side of the valley, the series embraces at Coatesville an enormous preponderance of the slates over the white sandstone, the upper Primal slate having a thickness of at least 700 feet, while the chief bed of the white sandstone measures no more than 30 or 35 feet. (See Sections.)

Fig. 22.—Section North of Coatesville, looking N.E.



Following the formation westward along the same outcrop N. of the valley, we find it well exposed near Parkesburg, at the passage of Buck Run through the ridge. Here the belt appears to contain three outcrops, in a denuded, anticlinal, and synclinal flexure, its whole width from

Fig. 23.—Section, Hill North of Parkesburg, looking N.E.



the limestone to the gneiss being a little less than one-third of a mile. In the vicinity of Parkesburg the strata, in descending order, are as follows : —

1. The upper or newer Primal slates, possessing a total thickness of about 700 feet, are subdivided by an intercalated thin bed of yellow sandstone, situated here very near the middle of the group, which may be regarded as the upper Primal sandstone of Coatesville and Chiques Ridge. Above this upper sandstone there are 300 feet of thinly-laminated micaceous slaty strata—internally, olive brown—externally, very brown and ferruginous. These contain in their lower part thin layers of white sandstone.

The yellow sandstone is itself about 200 feet thick, and between it and the micaceous slate occurs an alternation of thin and slaty layers of sandstone with the ordinary Primal slate. Underneath the yellow sandstone there succeeds another group of laminated slaty strata, some 350 feet in thickness, resting upon the upper beds of the main deposit of white Primal sandstone.

2. The middle or white Primal sandstone member of the series is in this neighbourhood about 50 feet thick. In its southern or first outcrop, north of Parkesburg, it is quarried in one or two places, and being very evenly and thinly bedded, it affords large slabs, well adapted for building and for flagging. On the surface of some of these we discern the characteristic broken crystals of black schorl in more than usual size and abundance.

3. The lower member of the Primal series, a thick group of brown silicious slates, more or less talcose and micaceous, is generally too much obscured at its outcrop by a covering of fragmentary matter, derived from the sandstone crest of the ridge, and from the adjoining gneiss, to enable us accurately to estimate its thickness; but this cannot be less than 300 or 400 feet.

These strata, especially the upper and the middle groups, are well exposed on the Strasburg Turnpike, immediately north-west of Parkesburg; and the middle member, or the white sandstone, conspicuously so in the gorge of Buck Run, one mile east of the village.

Under about the same type, the Primal rocks range forward to the Westward into Lancaster County, and we meet them in approximately the same relative development in their next outcrops to the N., namely, in the Mine Ridge at its Eastern spurs.

This narrow regular belt of the Primal strata in the North Valley Ridge keeps its course insulated between the Auroral limestone on its S., and the gneiss on its N., the whole way to the Westernmost Branch of the Octorara Creek in Bart Township, where, by the cessation of the gneiss, it coalesces with another and broader belt of Primal rocks, that of the Mine Ridge. To the description of this belt we next proceed.

Fossils.—The only fossil known to exist in the Primal rocks in Pennsylvania, the *Scolithus linearis*, is to be met with abundantly in the Primal white sandstone in the line of outcrop we have been tracing, especially in that portion of it which is embraced between Downingtown and Valley Forge. At the foot of the ridge, for a mile east of Ayer's store, specimens of this simple cylindrical form, arranged perpendicularly to the bedding of the sandstone, are numerous by the roadside.

MIDDLE BELT OF PRIMAL ROCKS NORTH OF THE LIMESTONE VALLEY, OR THAT OF MINE RIDGE AND ITS SPURS.

Between the synclinal trough of Auroral limestone terminating westward in Drumore, or the same basin prolonged through the Primal rocks to the Susquehanna, near McCall's Ferry as a Southern limit, and the South edge of the limestone of the Pecquea and Conestoga Valley, there spreads a broad undulated tract of the Primal rocks, embracing a number of short, narrow, insulated basins of Auroral limestone, divided from each other by anticlinal waves, which elevate the lower Primal slates to the surface, but nowhere bring to view the subjacent gneiss rocks.

In this district the more prominent stony ridges consist of the Primal white sandstone, but by far the largest extent of the surface eastward of Big Beaver Creek, a tributary of the Pecquea, belongs to the Primal slates. There we may recognise a series of little limestone basins. This general anticlinal zone rapidly contracts as it extends Eastward between the range of gneiss, which now bounds it on the S. and the limestone of the Pecquea basin on its N. It there begins to take the name of the Mine Ridge, and under this title extends until it is opposite the Eastern end of the Pecquea Basin. The narrowest and lowest part of this ridge is at the notch called the "Gap," through which the Columbia Railroad passes, and where its summit is not quite 500 feet above the level of the ocean. The width of the ridge, or rather of the belt of Primal rocks, in this vicinity, does not much exceed half a mile. There, and to the Westward for some distance, the structure of the Mine Ridge is very simple; it is composed of the three members of the Primal series already described, the white sandstone being in considerable relative force, and the whole undulated into one synclinal with one anticlinal wave; or, in other words, into three moderately gentle dips. That margin which reposes against the gneiss, dips rather steeply from it, or Northward; but this dip is succeeded near the gap, or central crest of the ridge, by an anticlinal flexure making a South dip and a second North one, the beds affected b ythe latter descending beneath the limestone at the foot of the hill. Advancing Westward, the only difference in the structure of this elevated zone of the Primal rocks is, that additional anticlinal flexures introduce themselves from the Westward into the belt, until in the longitude of Big Beaver Creek we may count at least six of these waves.

In the opposite direction, or Eastward from the "Gap," the structure of the Mine Ridge becomes complicated in a different manner by the appearance of a succession of anticlinal spurs N. of the main crest. If we trace this out to its Eastern termination, we shall find it ending W. of the West Branch of Brandywine in a long trough or synclinal point, and N. of this we may notice a long narrow anticlinal belt of the Gneiss rocks coming in from the E. to divide this spur of the Mine Ridge from another basin of Primal strata lying yet further N. in the centre of West Caln Township. Nearly W. of this uplift of the Gneiss rises an anticlinal spur of the Primal sandstone, N. of the true Mine Ridge, and projecting forward into the South-eastern corner of the limestone basin of the Pecquea, enclosing a little synclinal cove of that limestone between it and the main ridge. Still advancing Northward to the North boundary of Caln and West Brandywine townships, we reach another and much longer synclinal belt, prolonged from the Mine Ridge, but quite out of line with it. This is divided in part, or towards the E., by a narrow strip of uplifted and denuded Gneiss, penetrating across the West Branch of Brandywine, some three miles, to within a couple of miles of the limestone in the neighbourhood of Compassville. It is probable that the anticlinal wave which uplifts this second belt of Gneiss is the same with that which arches into a ridge or spur of the Primal rocks a little N. of the above-named village. In any case, it is obvious, from the structure and topography of the district, that the two or three successive spurs which protrude themselves Westward into the Limestone Valley, to enclose as many lesser valleys or synclinal coves of the Auroral strata, are the results of the gradual declension in that direction of so many undulations that further Eastward are in sufficient force or elevation to lift out the Gneiss.

The most Northern of the three synclinal ranges, into which that of the Mine Hill may be said to expand itself in its progress Eastward, terminates in a low point W. of the North Branch of the Brandywine, near Springtown Methodist Church. Traced thence Westward by the Manor Presbyterian Church, it extends in a widening belt, and, crossing the West Branch of the Brandywine, becomes the broad and but little cultivated belt known as the Barren Ridge, the crest line of which follows nearly the boundary between West Caln and Honeybrook townships. The Northern edge of this belt is defined by the Southern margin of the Gneiss from Indian Run Valley to the Pecquea.

Between the Western end of this belt, which may be viewed as terminating near the line which separates Chester and Lancaster counties, and the South-western end of Welsh Mountain, there extends, nearly in its line of prolongation, a narrower outcrop of the Primal rocks intervening between the Gneiss on the W. and N., and the limestone of the Pecquea basin. It is probable, however, that this strip of the sandstone along the margin of the valley is not everywhere discernible, for the district presents indications of a succession of faults, extending Westward from the Gneiss into the limestone, and bringing these two formations into contact by engulfing and hiding from view the interposed Primal series.

NORTHERN BELT OF PRIMAL ROCKS NORTH OF THE CHESTER COUNTY VALLEY, WELSH MOUNTAIN, &c.

The third and last principal belt of the Primal strata N. of the Limestone Basin of Chester County, is that of the Welsh Mountain and its Spurs. It commences about four miles E. of Morgantown, where the Mesozoic red sandstone overlaps the end of the ridge, and extends in a direction a little S. of W. to a point about two miles south of the village of New Holland.

In this belt the white sandstone is not as firmly cemented a rock as it is in the North Valley Hill. Advancing Westward, the ridge assumes a more systematic anticlinal form (see general Section V.), the sandstone dipping in both directions beneath the Matinal limestone; and as the axis sinks, the upper slates, which are of a dark-brown colour, occupy the surface, and hide the sandstone. Where the axis is high, as near the Sorrel Horse Inn, two and a half miles from Churchtown, the sandstone formation exhibits marks of much more igneous action than in other parts of the range. It is partially vitrified, very compact, and traversed by innumerable planes of cleavage, with imperfect crystallisation. This is not the result of contact with any igneous rocks, for the nearest trap-dyke is distant more than half a mile, and has produced but little alteration in the limestone in its immediate neighbourhood.

In this belt we meet with all the three divisions of the Primal series which characterise it in the North Valley Hill, and in Chiques Ridge at the Susquehanna; but the Primal white sandstone member appears to be in yet greater force than in any of the outcrops situated to the S.E. The general structure of the main Welsh Mountain seems to be very analogous to that of the Mine Ridge near the "Gap." In other words, it consists of an anticlinal and a synclinal wave, and, towards its Western end, appears to be still further complicated by the rising of another shorter anticlinal, entering it from the Gneissic district to the E., to form its Westward spur. The upper or newer Primal slates, reposing upon the white sandstone, are in some places excessively ferruginous at their uppermost limit, where they alternate with the lower beds of the Auroral magnesian limestone, so that large accumulations of iron ore may be looked for at the North base of this ridge, where the limestone of the Morgantown or Conestoga Valley is in contact with its strata. It is precisely under these relations, both as respects the geology and the topography, that the large mine called Jones's occurs near the head of that limestone valley, two and a half miles N.E. of Morgantown.

I have intimated in another chapter, that there exists a prolongation of this band of Primal rocks, not quite in line with the axis of the Welsh Mountain, but nearly a mile to the N. of it. This belt extends from near Jones's Mine eastward for about three and a half miles to Pine Creek, terminating about one and a half miles N. of the Warwick Iron Mines. Like the Welsh Mountain, it has a stony surface, a sandy and sterile soil, and is covered almost entirely with forest. These two Primal ranges are probably connected by a neck of the same strata between Springfield and Jones's Mines ; but the surface there being low and much obscured by the untilled swampy tracts which form the water-shed between the Conestoga and the South Branch of French Creek, the continuity of the Primal strata cannot be easily made out.

The extreme Western point of the Primal strata of the Welsh Mountain is at Mill Creek, near the Old Peters Road. The Welsh Mountain is the N.W. boundary of the Gneissic district of Chester County. From its Western spur, the view over the fertile and highly-cultivated plains of the Conestoga is, in the month of June, when the crops are ripening, extremely attractive, for this is one of the most fertile and best-tilled of all the grain-fields of the United States. The charm of the landscape, in which the middle distances abound in all the features of agricultural beauty, is not a little enhanced by the contrast between the fertility of the plain and the wilderness-like aspect of the background of forest-covered hills, or mountain-spurs, by which the scene both S. and N. is bounded.

INSULATED ANTICLINAL RIDGES OF PRIMAL SANDSTONE.

There is a low insulated hill of the Primal rocks a little N. of the Welsh Mountain, and rather more than one mile W. of Churchtown. It is somewhat more than one mile in length. Its structure is anticlinal, and the limestone on both sides dip from it. It marks the position, therefore, of a flexure of some magnitude.

Another rather longer tract of very similar form is situated about three miles N. of Lancaster, near Neffsville. This is likewise anticlinal in its structure, is surrounded by the limestone, and is the crown of a short axis, of which there are many in the adjacent limestone which do not thus protrude the Primal series.

INSULATED BASIN OF SEDIMENTARY STRATA WITHIN THE NORTHERN GNEISSIC AREA OF CHESTER COUNTY.

That there should occur in the interior of the Gneissic district of Northern Chester County one or more insulated synclinal belts or troughs of the Palæozoic strata, ought not to surprise us after what has been already disclosed of the existence of a succession of anticlinal and synclinal undulations in the Western part of the district, and of the series of synclinal dislocated basins in the very heart of the region, containing long lines of iron ore. The most conspicuous detached basin of newer rocks, resting within the Gneiss, is one in the West corner of West Vincent Township. It is a long belt of Primal white sandstone, which here forms a regular ridge elevated above the general rolling plain of the Gneiss rocks, and known in the neighbourhood as the Black Horse Hill. Its length is about two miles, and its breadth is not less than 2000 feet. From the crumbled condition of the sandstone at its outcrops, and the absence of any quarries or good natural exposures, it is impossible to recognise the dip of the strata ; but that these constitute a synclinal belt or outlying trough is very obvious. It is worthy of note that this tract of Primal sandstone lies nearly in the range of the long synclinal trough of that rock, forming the hilly belt known as the Barren Ridge west of the North and West Branches of the Brandywine.

COMPOSITION AND LIMITS OF THE PRIMAL SERIES OF THE NORTH VALLEY HILL NEAR VALLEY FORGE AND WESTWARD.

That section of the North Valley Hill which extends from its Eastern termination E. of Valley Forge to Lancaster County, contains all the three upper formations of the Primal series in full development, though, from metamorphic action, under a greatly-altered aspect. The main central crest of the ridge marks for the most part the outcrop of the sandstone or middle member of the series, while the lower Primal slate occupies the Northern flank, and the upper Primal slate the Southern.

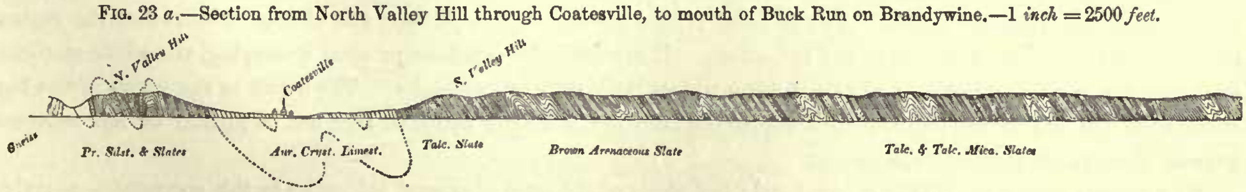
These slates have each a thickness of several hundred feet, but the sandstone embraced between is nowhere of great bulk, indeed seldom exhibiting a diameter of a few yards, and nowhere 100 feet. The slates are chiefly silico-argillaceous rocks, as may be easily seen, where they are in their normal condition in the belts further to the N.W. There they are ordinary sandy slates, with included beds of argillaceous sandstone; but along these more metamorphic Southern ranges bordering the Chester County Valley, their structure and aspect display almost the extremest degrees of metamorphism of which argillaceous strata are susceptible.

The visible boundary of the Auroral limestone, as marked by the overlapping edge of the Mesozoic red sandstone, is traceable from Port Kennedy to near the Eastern point of the North Valley Ridge; but at the foot of Mount Sorrow the slates of the Primal series emerge to view in contact with the margin of the red sandstone, and from this point forward to the W., as far as the point of first appearance of the Gneiss, the border of the Primal slate is defined by the undulating boundary of the red rocks—namely, over the Northern flank of Mount Sorrow, and across Valley Forge Creek at the Dam. But from the Eastern apex of the belt of gneiss near the Baptist Church, the margin of altered Primal rocks defined from this point onward by that formation, trends off somewhat more South-westward, assuming a higher position on the Northern slope of the main ridge. The precise place of the line of contact of the Primal and Gneissic rocks is not susceptible, in many parts of the ridge, of exact determination; yet the boundary can be sufficiently well inferred from the external features, the change in the soil, and the surface fragments. Guided by these signs, and by occasional outcrops of both formations, we can follow the limit along the Northern slope the whole way to the point in the spur of the ridge where this first breaks down at the passage of the road which leads down its flanks into the valley, and also at Ayer's Store. From the Valley Forge Creek to this gap or depression, the ridge is very straight, even, and continuous, and is everywhere crowned by the outcrop of the hard, altered Primal sandstone, which appears to have been trenched away by a rush of waters through this depression. Here, and at the crossing of the road from Pickering Creek towards the Paoli, it is easy to recognise, on the Southern slope of the ridge, the upper Primal slate in the condition of a talco-chloritic crystalline slate; but it is more difficult to detect the lower Primal slate of the Northern slope of the hill. This is beautifully exposed at Valley Forge Creek, is cut in the Pennsylvania Mining Company's shaft, and is visible frequently in fragments on the Paoli and the other roads over the ridge; but it is not generally discernible in place, being extensively covered by the fragments and the sand of the Primal sandstone of the crest of the ridge, swept over it by retreating waters.

The actual constitution of these Primal schists is that of talco-chloritic slates, in which the talco-chloritic and quartz constituents are distinctly segregated, and in many portions thoroughly crystallised. Indeed, so completely are these masses converted to the structure and composition of the talco-chloritic schists of the genuine Gneissic family of rocks, that they have hitherto been invariably referred to that group; and it is with much difficulty that a geological observer, not intimately acquainted with the phenomena of metamorphism in the rocks of our Atlantic Slope, can persuade himself that these are genuine Palæozoic masses, or beds of a fossiliferous age, converted by mere igneous agency to the antique aspect they present. But a study of the gradations or alterations assumed by these strata, as they may be traced from the zone of maximum change to the districts of least transformation further N.W., puts the correctness of this conclusion beyond all doubt.

The Primal sandstone, as it presents itself along the two lines of outcrop bordering the Chester County Valley, exhibits nearly all the varieties which belong to it where it is thickest and most largely developed elsewhere, whether we compare it with the Potsdam Sandstone of New York, or with the mountain masses flanking the North-western slopes of the Blue Ridge in Virginia and the States further S. Here in Chester County it contains, besides its typical beds of pure white and yellowish white quartzose sandstone, some other members, especially coarse loosely-aggregated sandstones, and fine-grained silicious conglomerates. Notwithstanding the excessive heat to which these rocks have been subjected, they have not been at all fused, nor have their obscure *organic relics* been obliterated. Indeed, the Primal sandstone of the summit of the North Valley Hill contains in great abundance, even where it has been baked and indurated, the curious stem-like fossil, the *Scolithus linearis,* so distinctive of this formation. Though convinced for many years past, from structural evidence, that this crest rock is the true Primal or Potsdam sandstone, yet my recent discovery (in July 1853) of this organic form, the earliest type of living organism in any American formation, affords a satisfactory confirmation of the soundness of the deduction.

FIG. 23 *a.*—Section from North Valley Hill through Coatesville, to mouth of Buck Run on Brandywine.—1 *inch* = 2500 *feet.*



IRON ORES OF THE PRIMAL STRATA.

Jones's Iron Mine in the Southern Corner of Berks County.—This extensive and valuable iron-mine belongs to the Warwick Iron Company. It is near the eastern extremity of that branch of the Conestoga Limestone Basin of Lancaster County, which extends into the southern angle of Berks, under the name of the Morgantown Valley, N. of the Welsh Mountain. The mine is about two and a half miles north-east of Morgantown. Its geological position is in the upper Primal slates, just at the base of the Auroral magnesian limestone. More correctly, this ore is the upper Primal slate itself, or its highest beds rather, in a very ferruginous condition. In this and several other respects its relations are strictly the same as those of the great iron-ore deposit of the Cornwall Mines in Lebanon County.

The chief mine is an opeu excavation, covering rather more than five acres; and there is another to the south of it occupying about one acre. Magnesian limestone bounds the ore on the northern edge of the principal excavation. Here there is a mine-shaft 180 feet deep, with a competent steam-engine. The shaft enters the limestone at a depth of 50 feet from the surface, and a boring, descending 20 feet from the bottom of the shaft, is still in this rock.

A dyke of trap-rock cuts the ore-bearing strata near the southern side of the pit, and produces phenomena precisely identical with those caused by the trap-dykes in the Cornwall Lebanon Mines, converting the ore to a more highly crystalline form, and endowing it partially with magnetism. As in every such instance, the ore is richest and purest adjacent to the trap-dyke. This is equally the case in the southern or smaller mine. The strata dip to N. 30° W. at about 20°; and in the northern bank of the large mine, we may perceive the Auroral limestone regularly overlying the upper beds of the Primal slate, containing or consisting of the ore.

This miue has been wrought with more or less activity for the past seventy years. Its product in 1853 was about 7000 tons, and this is stated to represent the average yield for the last twenty years, while for the previous fifty years the annual amount furnished is given at about half as much.

In this mine, as in that of Cornwall in Lebanon, some of the ore contains a small amount of copper, in the form chiefly of sulphuret, carbonate, and silicate of copper. To extract this copper ore has beeu a favourite thought with some metallurgists for several years past, and about five years ago, an elaborate and expensive experiment was undertaken with this object by the American Mining Company of New York. They crected at the mines machinery for crushing and grindiug the ore, and a costly apparatus, consisting of cylinders bearing a multitude of magnets and brushes for withdrawing the pulverised magnetic oxide of iron from the copper ore, and other constituents. This enterprise has proved to be unprofitable, partly from the difficulty of effectiug a thorough separation, partly from the want of a sufficient abundance of the essential element, the copper ore. Including the cupreous iron-ore mined within the four years of this undertaking, the whole annual product was uot less than 10,000 tons.

Iron Ore Bank of Chestnut Hill, near Columbia.—This large mine is situated about three and a half miles north-

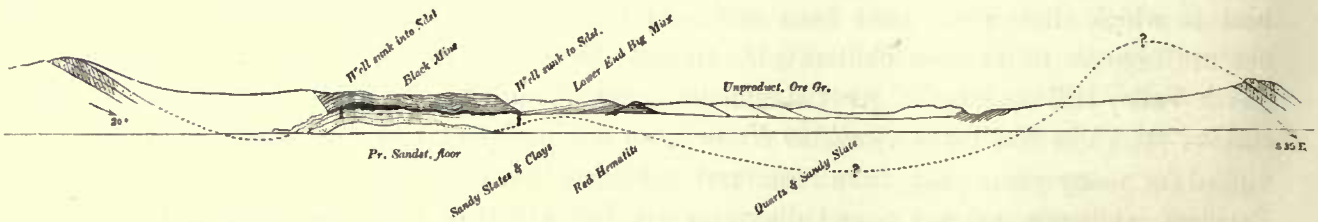


FIG. 24.—Chestnut Hill Ore Bank, 3 miles N.E. of Columbia, Lancaster County.—1 *inch* = 500 *feet.*

east of Columbia, in a high trough-like valley or basin on the slope of Chestnut Hill, a spur of Chiques Ridge. The structure of the valley is apparently synclinal, the dips gentle, and in the central portions nearly flat. The ore lies in the lowest layers of the Primal newer slates, the very same formation which contains the ore in the Cornwall, Jones's, and Safe-Harbour mines. As the mine is now developed, it is perhaps the clearest illustration the region affords of the geological relatious of the Primal ore. It is worked by benching or open quarrying, the whole material enclosing the ore being in many parts cut down perpendicularly in steep banks. The depth in the centre of the big mine, from the soil to the bottom rock supporting the ore, is about 100 feet, and ore of greater or less richness prevails throughout this entire thickness.

The present excavation (1856) covers nearly the whole of the tract of ground belonging to this one estate—namely, about eleven acres; but undoubtedly this is not the full extent of the ore-bearing ground. Indeed, the existence of a rich large mine, owned by the Messrs Grubb, almost half a mile to the eastward, shows that the ferruginous deposit has a wide range.

The ore-embracing stratum has been dug through to the supporting rock in several places. In each such instance the floor is the upper surface of the Primal white sandstone. In some places the first layers of this rock are a pale yellowish sandy slate; but, penetrating a little farther, the hard white sandstone invariably appears. It would seem, therefore, that the ore all lies within the first 80 or 100 feet of the newer or upper Primal slate. This slate, throughout the upper 40 or 60 feet or more—the thickness varying with the amount of the formation—is now in a thoroughly disintegrated condition, being in the condition for the most part of a bluish, yellowish, and white laminated unctuous clay; but it still retains, more or less distinctly, the stratification or intimate foliation of the original slate. Though approximately horizontal, the layers display a wavy bedding, the result seemingly of an undulation of the strata primarily impressed, and not a consequence of any washing in of ore or clay deposits.

Beneath this rather regularly bedded ore-containing slate, there lies throughout a large part of the mine an irregular deposit or bed of rich solid concretionary ore, extending under a variable thickness of 10, 20, and 30 feet, down to the top of the Primal sandstone. (See Fig. 24 *a.*)

It is evident that this ore, which is a brown cellular fibrous hæmatite or limonite, has been derived from the filtration of the oxide of iron, from out the ferruginous slates above, which show in their condition of meagre clays, that they have been thus completely leached by water. The surface of the Primal sandstone is even now a water-bearing plain, for it is only here that water is met in sufficient quantities for domestic use, in and near the mine. Consolidated layers of the brown ore are also seen overlying certain of the more impervious layers of the clay-slate, as if this also at one time arrested the descent of the ferruginous particles.

Possibly a part of the undulation of the strata may be due to the upward bulging action of the ore, as this was accumulating and concreting from above, such as we know took place in the gypseous strata of Western New York from the collection of great cakes of plaster on an impervious floor of shale.

An interesting inquiry is here suggested as to what can have been the geological atmospheric condition which produced the remarkable percolation which carried down so large an amount of ore out of these ferruginous beds. Was it tepid rain, charged with carbonic acid, in an early Palæozoic period? or could it have been a long filtration of surface waters, such as now soak the earth? or are we to surmise an action of internal steam issuing upward through crevices in the strata, in a period of crust-movement and disturbance? I am inclined to the first conjecture.

It is worthy of note, that only in one spot in the mine do we meet with a crystalline magnetic ore. In the old or large mine there is a band of this ore, three or four inches thick, containing small but beautiful octahedral crystals; everywhere else the ore is the common brown peroxide of iron. From this fact it would appear that this Chestnut Hill deposit was invaded by a less energetic metamorphic action than that which attacked the Cornwall and Jonestown strata, where the crystalline and magnetic condition, due to heat, is the prevailing state, and not the exception. At what stage or period did this metamorphism of the ore take place? Was the oxide of iron of the Cornwall and the Jones's Mine primarily deposited as a part of the slate, and crystallised at the time of the metamorphism of all the Palæozoic rocks? or did the ore originate from out of the ferruginous slate by a process of percolation, bringing together its particles, previously intimately diffused there, the heating, altering action arising afterwards? I am disposed to think that the ore was collected from the substance of the rock, and then metamorphosed. But this is at the present a somewhat obscure inquiry. Probably the Palæozoic masses underwent more than one action of upheaval, undulation, denudation, and metamorphism; one perhaps at the end of the Matinal age, and a final one at the close of the Coal period.

Fig. 24 *a.*—Section of Iron Ore at the base of the Primal Slate, Chestnut Hill Mine.

CHAPTER III.

PRIMAL STRATA ON THE SUSQUEHANNA AND IN YORK COUNTY.

The Primal rocks occupying the Southern townships of Lancaster County, and the whole South-eastern angle of York County, are admirably exposed for geological study in the deep and cliff-lined valley of the Susquehanna, from Marietta to the Tidewater at Havre-de-Grace. I propose, therefore, to illustrate this portion of the Southern zone by a detailed description of these strata, as they are displayed along the West bank of the river, where the fine natural section has been aided by numerous cuttings for the Tidewater Canal, appealing to the elaborately constructed profile of the rocks for future elucidation of the structure and features of the region. One such carefully-compiled continuous section furnishes a better conception of the geological composition of the district, than any multitude of unconnected notes drawn from detached localities. This has been surveyed and drawn up with care, and will therefore supersede the necessity of much detailed description of the surface phenomena of the Slate country E. and W. of the river, where, in truth, there is extremely little variety in either its geology or mineralogy.

DESCRIPTION OF THE SUSQUEHANNA SECTION.

The Susquehanna River, throughout its entire length from Marietta to where its waters merge into those of the Chesapeake Bay at Havre-de-Grace, occupies a deep broad valley, varying in width from a few hundred feet to more than a mile. On either shore it is for the most part bounded by rocky bluffs supporting table-lands, at an elevation of from 100 to 500 feet above its waters. These bluffs exhibit a grand natural section of the whole group of the Primal series, constituting the base of our Palæozoic system.

Leaving the Auroral Limestone Valley of York and Wrightsville at Creitz Creek and proceeding Southward, we pass a belt of hills about two miles in width, which elevate Primal rocks high above the river-level. They indicate the presence of at least two folded anticlinals, which, coming in from the South-west corner of York County, cross the Susquehanna below Columbia, and droop away at the West Branch of the Little Conestoga Creek, where the limestone laps around the base of the hills. In a little cove between these two anticlinals exists a narrow trough of impure limestone, seen on both banks of the river. In the hill N. of this cove, there is no appearance of Primal sandstone, the strata consisting exclusively of the Primal upper slates. Under conditions of partial metamorphism, they present themselves as dark-blue silicious slates, with the cleavage surfaces glazed, and in some places speckled with crystals of sulphuret of iron. The wider belt of Primal strata below the cove, like the former, is chiefly slate. There are two bands of Primal white sandstone, neither of which exceeds one hundred feet in thickness. If our construction of dips is correct, they form the two limbs of the folded anticlinal.

It should be observed that the planes of true bedding are very obscure, being almost entirely obliterated by the cleavage, which intersects the rocks by an infinite number of parallel planes. The planes of cleavage are nearly or quite parallel in strike with the planes of bedding, though they dip at a high angle, ranging from 70° to 90° S., 15°—20° E.

This wide anticlinal belt of slate stretches southward in an almost straight course, with a slight increase in its breadth, entirely across York County, into the extreme South-east corner of Adams County, and thence into Maryland. It is bounded N.W., throughout its whole length, by the York and Hanover Limestone Valley, or that of the main Codorus and Creitz Creeks, and S.E. by the narrow limestone trough of Cabin Branch Run, and the other shorter limestone basin of Jefferson. The structure of this belt is that of a broad flattened anticlinal arch, with one or even more synclinal depressions in its middle. Only in a few localities does it expose Primal white sandstone.

A somewhat promising locality of roofing-slate occurs in this ridge about two miles south of the York and Wrightsville Railroad.

One mile south of Hanover, we meet the line of contact between the limestone and slate ranging N.E. and S.W., and, passing half a mile south of Littletown, bringing the margin of the slate to the Maryland line near Arnold's Mill. The limestone belt of the York Valley, lying on the N.W. of the slate, terminates near this spot in a wedge-shaped point, by the folding round of the overlapping middle secondary red sandstone, which, after concealing the limestone, encroaches upon the slate.

From the belt just described, which has its southern limit on the west bank of the river at Cline's Run, and on the east bank at Charlestown, we enter upon a limestone valley about two and a half miles broad. This somewhat corrugated basin constitutes the south-western prong or branch of the great Conestoga limestone. It tapers westward in a very slender folded belt, terminating in a point at the Eastern Branch of Codorus Creek; but it is extremely narrow only three miles west of the river, at the old Margaretta Furnace. It is quarried in two or three places near Cabin Branch Run. It contains a rather interesting stratum of somewhat coarse, calcareous conglomerate, consisting of lumps of grey limestone, imbedded in a dark slaty cement. This band is about one hundred feet thick, and occurs about a mile and a half above Beig's Mills. The furnace was supplied with ore from the northern margin of the slaty limestone at its junction with the Primal slate.

At the river the limestone exhibits a high degree of metamorphism; it is silicious and magnesian, imbedding thin layers of talc-slate and segregated quartz. The flexures, so far as they can be clearly made out, are gentle. The cleavage dips uniformly Southward at a high angle.

The synclinal trough of altered Primal slates, embracing this fold of the limestone, somewhat expands to the S.W. and near the South Branch of the Codorus, or about a quarter of a mile west of the York and Baltimore Railroad; and ten miles nearly south of York, admits another narrow trough of limestone. This rock is quarried on the farm of Mr Daniel Diehl. South-westward from Diehl's, towards Jefferson, it is excavated at several other localities, and converted into lime for the fields. At Christian Knull's, east of Jefferson, we meet with indications of iron-ore in it.

We now enter upon that extensive area of barren rocks which first appears a little west of the Schuylkill, forms the southern boundary of the Chester Valley, and covers the southern portion of Lancaster and York counties. These rocks we are forced, after close study, to regard as constituting the base of the Primal system, though so altered as to have been hitherto mistaken for true Hypozoic metamorphic rocks of the Gneissic group. The reasons for this conclusion will be given elsewhere. They sustain the high table-lands through which the river flows, and constitute the rocky bed of the stream, above which the harder masses project, forming multitudes of little islands. Descending the river, the boundary shores approach each other, and their dark, wood-covered and rocky sides give to the scenery a wild and picturesque character.

The precise line of contact of the limestone with the talcose slates is not clearly visible on the west side of the river; indeed, there seems to be no line of sudden transition. The lower bands of the limestone, naturally more slaty than the higher strata, have themselves undergone so much metamorphism as to be scarcely distinguishable from the Primal slates.

For convenience in description, we shall first consider the belt of rocks included between the limestone on the N., and the mouth of the Conestoga on the S. The first and most notable fact is the great apparent uniformity in the direction of the dip, which throughout this entire distance is towards the N.W., varying from 15° to 45° W. of N.

On the east side of the river the high table-land of Turkey Hill, formed of the rocks now under consideration, sends forth several spurs or fingers towards the East, all of which droop away only a few miles from the river, permitting the limestone to take its place at their extremities. These fingers are evidently of anticlinal structure. From examination of the Section, it will be seen that several close folds may be constructed from the dips in this belt.

It is interesting to observe that the *axis planes* of these folds all dip towards the N.W.; in other words, in a direction *opposite* to that which the Appalachian system of flexures usually observes.

The *cleavage* throughout this belt is very distinctly defined. From the limestone to Green Branch Run, two miles below, it fluctuates from one side of the perpendicular to the other, but not more than 10° either way. Its strike is S. 50° — 60° W. The strike of the cleavage thus changes to S. 75° W.; but approaching Lockport the planes of bedding become more conspicuous than those of cleavage, and in the flatter dips the scales of mica predominate in the bedding. The cleavage thus becomes less and less obvious, and at Lockport has entirely disappeared as a distinctive phenomenon.

Starting from the lower limit of the synclinal valley of Cabin Branch Run, which, on the eastern side of the river, is nearly coincident with the south bank of Wistler's Run, and examining the *composition* of the strata of the slate belt forming Turkey Hill and its extension westward, we may define the whole tract, as far as Lockport, to consist of the Primal slates under the condition of Micaceous, Talco-micaceous, and Gneissoid Schists of a prevailing greenish-grey hue. Throughout this space the north-westward dip exhibits no change to the S.W., but only varies its inclination, sometimes fluctuating suddenly as if from a close fold in the strata, but displaying on the whole a progressive declension in its angle from an average of 75° or 80° on the northern side of the belt, to 30° as we approach Lockport.

On the cleavage planes, which for the most part, as already stated, are very steep, we see in some places numerous small lenticular plates of segregated quartz. These obey the general law of parallelism to the cleavage structure, and not to the original bedding, and they afford an instance of that mode of molecular crystallisation of the elements of the rocks which, carried further, has produced, I conceive, the foliation or grain in all mica-slates, gneiss, and other completely metamorphic rocks.

Pursuing the line of section southward, down the west bank of the river, it will be seen that, passing Lockport, the mica-slates grow more gneissoid, or become more coarsely crystalline, with a more distinct development of their constituent minerals, and this semi-gneissic character prevails as far as Shenck's Ferry. In some portions of the mass, the foliæ of the mica-slate enclose plates of segregated quartz. The same dip which prevails above Lockport, continues to within a few hundred feet of Shenck's Ferry, the angle varying from 45° — 20°, the direction N.W. Near the Ferry commences a series of low undulations, to be specified presently. As already intimated, the true cleavage structure disappears a little above Lockport, and therefore no portion of the belt now under review displays this phenomenon; nor indeed do we meet with it, unless once or twice very locally, anywhere to the S. of this neighbourhood within the broad metamorphic zone crossed by one section. This disappearance of slaty cleavage, and acquisition of a more highly crystalline structure in the rocks, is in strict accordance with that view of the origin of both, which ascribes them to a crystallising polarity among the mineral particles excited by a high subterranean heat, the difference between the slaty structure and crystalline foliation being merely the result of a difference in degree of the rearranging force among the mineral particles.

A little more than half a mile below the dam near Lockport, there is a slender dyke of trap-rock visible, both in the canal bank and the river. It seems to dip steeply southward, intersecting the dip of the slates. This trappean dyke is very probably but a prolongation of the long curving injection of trap-rock which ranges from N. of the Conestoga, S.W. of Millersburg, and intersects the hills and valleys east of Safe Harbour, meeting the east bank of the river about a mile above Shenck's Ferry.

Passing now to the belt of country embraced between the vicinity of Shenck's Ferry and that of McCall's Ferry, we find ourselves still in the same group of talco-micaceous schists occasionally gneissoid, which have been already passed over from above Lockport. Indeed, there is but little essential variation either as to aspect or composition in the strata throughout the whole wide tract passed over by the Susquehanna from the limestone valley of Cabin Branch Run to the slate belt of Peach Bottom or Slate Point, the chief change being to a more gneissic character between Lockport and Shenck's Ferry.

The special belt before us, or that from the Ferry to M^cCall's, differs from the remainder of the region in containing several distinctly-marked broad undulations of the strata. There are, indeed, three anticlinal waves, all of which cross the Susquehanna towards the S.W. They are wide and flat, or show only gentle dips, the inclination on both flanks being nearly equal. The first of these flexures is visible in the hill just north of Shenck's Ferry; its dips are about 20°, the northern towards the N.W., the southern towards the S.W., showing that the wave itself is rapidly expiring westward. The next is a rather bolder, wider arch, occupying the whole breadth of the hill just south of the valley at the mouth of which the Ferry is situated. In this instance, likewise, both the N. and S. dips are deflected from westward, and at the very axis or summit of the wave the dip is nearly westward at an inclination of about 15°, that of the two slopes being about 20°. The valley of Shenck's Ferry is simply the synclinal trough formed by these two anticlinals. Some of the layers of talc-slate in the most southern of these anticlinals contain garnets.

The third, or most southern, is a gentle broad wave occupying the hill, terminating on the river at Duncan's Point. In it, the dips on both flanks of the arch are also nearly equal, not exceeding 15°. The whole anticlinal, like the other two, sinks towards the West.

The middle of the synclinal wave embraced between the last-named anticlinal of Duncan's Point, and that below Shenck's Ferry, is situated about two-thirds of a mile south of Otter Creek. Its S. dip is about 15°, its N. about 20°.

In the south bank of Otter Creek, one hundred yards from the river, is situated York Furnace, near to which there exists a band of limestone, not more than two feet thick, enclosed between talc-slate. It is impure, and not suitable for a flux for the smelting of iron-ores, though the more compact portions might make a lime fit for agriculture should the bed be discovered thick enough to admit of being profitably quarried. It appears to be merely a calcareous layer in the talcose Primal slate, and not a fold of the Auroral limestone.

Octahedral Iron occurs as a constituent of the talco-micaceous slates, in more or less development throughout the whole district, from Turkey Hill to Peach Bottom; but it seems to be more than usually abundant between the vicinity of Safe Harbour and Shenck's Ferry. It occurs abundantly in minute but beautiful crystals near Cooper's Point, below Peach Bottom, not far from the State line.

Purple *Sulphuret of Copper*, with a little blue and green *carbonate of copper*, enclosed in irregular veins of white quartz, were met with in excavating the canal at one of the deep cuts near Duncan's Point. These indications of copper ore were, however, very faint, and there was nothing to imply the existence, either at this or any other locality along the river, of a possibly profitable lode of copper ore.

Continuing our survey down the river, we pass over, between M^cCall's Ferry and Muddy Creek, very nearly the same class of micaceous schistose rocks already traversed higher up, the chief difference being that they are somewhat more gneissoid and abound less in octahedral iron. Throughout this belt there prevails but one general southerly direction in the dip. This is at all angles, from 20° near M^cCall's Ferry, to 50° in the vicinity of Muddy Creek, and is towards all points between S. 20° E., and S. 20° W., the former prevailing. This southerly dip continues, in fact, with one or two local interruptions, the whole way across the Slaty district, from the anticlinal at Duncan's Point to the zone of true ancient massive gneissic rocks and granite dykes south of the State line. There can be little doubt, however, that this is not a genuine monoclinal belt of strata, but one containing many closely-compressed inclined foldings, the axis planes of which, if detected, would be found to dip at low angles southward; for it is inconceivable that the strata here seen to dip so uniformly, should be of the enormous thickness implied by the supposition that they contain no flexures or repetitions of their outcrops. From the above-mentioned last visible anticlinal, to the first genuine plutonic or eruptive rocks, is a distance of at least eleven miles perpendicularly across the strike; while the average dip is as steep as 45° or 50°. The data imply a thickness of seven and a half or eight miles. The supposition of so huge a depth of regularly sequent deposits, is incompatible with the well-ascertained comparative thinness of the whole formation on the Brandywine, and more remarkably still on the Schuylkill.

But the existence of actual flexures, folded ones apparently, does not rest on inference; it is established by observation, as the portion of our Susquehanna section below Muddy Creek will clearly show. That such compressed folds do thus repeat the same strata many times over at the surface, is plainly indicated by a feature of the tract, well exhibited on the Map; I mean the running forward towards the N.E. of ridges and tongues of the slate, like that N. of Cabin Branch and Turkey Hill, into the limestone tract of Lancaster County, N. of its general southern boundary. These projecting tongues are but the terminations of the anticlinals which have thus lifted and spread out the slates below the limestone. When we follow this belt of metamorphic slates south-westward, through Maryland and into Virginia, this progressive expansion at the surface, and from the cause here presented, becomes still more conspicuous.

Returning to the special belt we have been describing, it will be seen by the section to exhibit much slaty cleavage or an abundance of foliation-planes. These fissures, seldom coincident with the planes of bedding, but for the most part steeper, dip like the bedding towards the S. Their prevailing inclination from M^cCall's to Muddy Creek, where the average inclination of the bedding is low, is as steep as 45°. From Muddy Creek southward, it is seen to become much steeper, until, in the vicinity of Slate Point, it mounts to 80° or 85°. Below Hough's Run, S. of Slate Point, it ceases to be conspicuous. This prevailing southward dip of the cleavage-planes, coinciding as it does with the very general southward inclination of the strata, is certainly a striking confirmation of the law, several times already enunciated, of the parallelism of cleavage-structure with the planes of plication. To one convinced, as the author is, of the generality of this law, where the zone of cleavage-structure is a broad one, the phenomenon is of itself a satisfactory indication of the existence of a system of inclined foldings, even where the metamorphism has completely obscured these.

The law here enunciated of the relation of cleavage to plication of strata, is not merely one of scientific interest,—it is of great practical importance, as every person may perceive who reflects that in districts really much convulsed, but which exhibit superficially but one direction of the dip, the miner or mineral explorer who might be deluded into costly outlays from the seeming uniformity and assumed depth of his mineral bed, will take warning at the indications which the cleavage may give him of shallow foldings and perplexing repetitions of the seams he may be pursuing.

From Muddy Creek to the vicinity of Peach Bottom, the river intersects the same talco-micaceous schists seen above, but growing finer grained as we approach Peach Bottom. In this space there appears to be an anticlinal flexure, the axis of which crosses the river a few hundred feet above the canal lock.

Slate-belt of Peach Bottom.—The next subordinate belt which the section crosses, is the slate range of Peach Bottom and Slate Point. The rock here is a dark-blue indurated clay-slate, much of which has the structure of roofing-slate, extensive quarries of which have long been successfully wrought at the Peach Bottom Cliffs on the eastern side of the river, and also at numerous points west of the river, in York County, and in Maryland. The workable slate-belt here is about half a mile wide. The slaty cleavage and the bedding appear throughout to be nearly coincident in their dip, which at the quarries is nearly perpendicular a little southward. The quality of the Peach Bottom slates is very good, and their exportation is slowly augmenting. The belt runs north-eastward through Slate Hill from the river, a distance of about two miles, and south-westward through York County from Slate Point, a distance of about six and a half miles to the State line. Slate-quarries have been opened N.E. of the river, along nearly the whole distance mentioned, but never extensively wrought, and in the same detached manner through York County. At Slate Hill on the river, the slate is quarried in steps or benches, and not in one general breast, though the material is so uniformly pure as to admit of being nearly all wrought. On the east side of the river there are seven quarries near the shore, and four others of smaller size back on the hills, which are at the present time unwrought. On the York County side there is only one quarry at the river, but in the interior of the county there are seventeen more, embraced between a point two and a half miles back, and the end of the range six miles from the river. The workable slate appears not to extend in Lancaster north-east of the limit given, but in the other direction there are indications that it is prolonged beyond the distance of the six miles named. One of the quarries on the river, Brown's Lower Quarry, yields slates which will bear strong stove heat without cracking, and the workmen use flags of it for frying their meat upon. So uniform is the composition of the material, and so diffused and regular the metamorphism, that the original planes of sedimentation or bedding are too indistinct at these river quarries to be discernible. The cleavage-planes, the only visible ones, dip about 80° to S., 30° E., and this condition prevails throughout.

Statistics.—During the year 1853 the quarries of J. and S. Brown yielded 1000 tons, and in the two preceding years 1500 tons. Caldwell's quarry, on the same north-east side of the river, yields annually about 400 tons. Cox's quarry, on the opposite side of the river, has afforded but a small amount; but much slate is wrought in York County, where one quarry, that of Roland Perry, the largest in the belt, produced, in 1853, about 2000 tons.

The *price* of slate for the last six years has ranged between $14 and $17 per ton.

Slates of the largest size, of 24 by 14 inches, were $69 per thousand; ditto 16 inches by 8 inches, $22 per thousand; ditto 12 inches by 6 inches, $12 per thousand.

In the extension S.W. of this general belt of Primal slates, there are five or more quarries wrought in Frederick County, Maryland, near the railroad eight miles from Fredericktown.

The next belt of strata cut by the river, and indicated on our section, extends from below Slate Point to the second canal-lock below the State line, a distance of about four miles. The rocks here exposed are various forms of mica-slate and talcose-slate, alternating with talcose white sandstone, certain outcrops of which bear the unmistakable characters of the Primal white sandstone. One or two outcrops of chlorite-slate occur, and occasionally the mica-slate graduates towards a micaceous quartzose gneiss. Much of the finer-grained talcose slate is undistinguishable from rock, so-called, which near the Schuylkill, and along the South Valley Hill, both east and west of it, and also in the anticlinals of the Montgomery and Chester Limestone Valley, is seen in intimate alternation with the Primal white sandstone. Either from the more frequent presence in this district of the middle part of the Primal series, the White Sandstone group, or from a less excessive degree of metamorphism, the strata here exhibit a far lower condition of crystalline change than in some of the tracts further N., having fewer of the features of true micaceous schists, and more of the characters of genuine sedimentary sandstone. Indeed, at several places between Slate Point and the State line, we meet with a rock which, in its composition, lamination, colour, fracture, and whole lithological aspect, is absolutely undistinguishable from the main bed of the Primal white sandstone, as it is seen in Edge Hill and other notorious localities of this readily recognised rock. One of the localities is just below Slate Point, the sandstone forming, in fact, the south flank of the Slate Hill, and reposing, regularly bedded, immediately upon the slate itself, which near the contact is highly nacreous, and in that minutely wavy or crinkled lamination which usually denotes a metamorphism approaching the rock usually called Talc-slate.

About 1700 feet further down the river, there is another outcrop of Primal white sandstone immediately north of Hough's Run at the canal lock. Here the rock is between 90 and 100 feet thick. It dips at the canal level 45° to S., 30° E.; but rising into the hill it grows flatter until it becomes nearly level, as if bending to form an anticlinal arch; indeed, it is difficult to resist the conclusion that these two South-dipping belts of sandstone are simply the two abutments of a wide fold or flexure, the northern flank of which is inverted into a somewhat steeper South dip than the southern. This view is confirmed by the crushed and contorted condition of the dark slates which fill the space between the outcrops of the sandstone. It is further confirmed by the presence in this neighbourhood, both within the supposed arch and at Slate Point above it, of a steep South-dipping cleavage, a feature quite usual in the slaty rocks throughout the district.

At other points further down the river, especially between Rock Run and the State line, a material having all the aspect of the Primal white sandstone under a more extreme condition of metamorphism reappears. We meet it again, though materially more altered and crystalline, about two-thirds of a mile below the State line, and here, as we should expect, it is in contact with a dark crystalline slate, precisely such as we find the talcoid slates of the South Valley Hill, Chester County, where, in alternation with the sandstone, they are more than usually metamorphosed. In truth, we encounter repetitions more or less frequent and distinct of this altered white sandstone and its contiguous slates all the way along the river to the mouth of the first stream in Maryland, more than a mile and half below the State line. In other words, we may recognise these outcrops of the Primal white sandstone throughout a belt nearly three miles and a half broad, from the south flank of the Slate Point Hill to near the crossing of the great belt of serpentine.

Serpentine Belt.—Passing out of the talcose and micaceous slates which, as already stated, extend for about two miles below the State line, we meet a narrow belt of Serpentine rock having all the distinctive features of the Serpentine of the southern border of Lancaster County, of which, indeed, it is but the prolongation. As in all the other localities where this formation has been met with, it is in contact with the talcoid or altered older Primal slates, immediately adjacent beds of which are frequently so impregnated with the magnesian mineral, and so changed thereby, as to seem at first sight like a stratified serpentine. This rock contains much green actinolite. The full width of the dyke is not at present visible, but is is manifestly very narrow when compared with the space occupied by the belt under the State line in Lancaster. Even here, however, its breadth, including the serpentinous slates associated with it, seemed at the time the canal was excavated to extend two hundred yards. Whether this slender outburst is connected with the extensive and broad tract of chromiferous serpentine barrens of Deer Creek in Maryland, or whether that is an independent and somewhat more southern range, we have not ascertained; but it is notorious that the magnesian rocks abound extensively throughout this zone to the S.W.

Almost immediately adjoining the outcrop of the serpentine at the river upon its south side, there is a slender band of gneissic chlorite rock. This is too imperfectly exposed to enable an observer to ascertain whether it is stratified or not, but the masses visible exhibit an indistinct irregular foliation, more suggestive, however, of slaty cleavage than of sedimentary bedding.

Gneiss and Granite Belt.—The last subdivision of the ancient rocks traversed by the Susquehanna is a broad belt consisting mainly of massively-bedded gneiss under its several varieties, and of mica-slate and hornblende slate cut by dykes of genuine intrusive syenite, granite, and greenstone trap. Perhaps the predominant rock of all is a thickly-bedded granitoid gneiss of the typical composition and structure assigned to that formation. It consists, in other words, of the three characteristic minerals, quartz, felspar, and mica; the quartz and mica predominant, and completely and widely detached, streaking the rock in light and dark wavy bands and blotches. This is the rock which is so extensively quarried on the east side of the river, north, and also south, of Port Deposit, and used by the Federal Government for the Delaware breakwater and other national works. Besides this prevailing variety, there is a broad outcrop near Havre-de-Grace of a more felspathic granitoid Gneiss of a yellowish and pinkish tint; it also is an admirable building-stone when large and coarse blocks of a durable material are wanted. Hornblendic gneiss, graduating into hornblende slate, likewise prevails. On the east side of the river, the southern limit of the crystalline rocks is one mile below Port Deposit, the shore farther south being Tertiary or Diluvium.

Of the *Intrusive Rocks,* the principal varieties are syenite and granite, the former more abundant than the latter. Wide dykes of a fine-grained grey granite are quarried near the canal about half a mile above the old Conewango Bridge, and a little further north there is a thick dyke of white igneous quartz. These granite dykes dip steeply south-eastward. An augitic syenite displays itself in several thick dykes about two miles lower, and this and other varieties of syenite abound in the neighbourhood of the mouth of Deer Creek. Near the vein of quartz above the Conewango Bridge there is a dyke of greenstone, but this rock is not abundant along the river. Above Havre-de-Grace there are noble exposures of the yellowish felspathic gneiss, not merely in the banks of the river but back upon the plain, where the edges of the strata are imperfectly covered by the attenuated margin of the horizontal tertiary sands and clays. Here the river, already a tidal estuary, expands into the Chesapeake Bay, the abrupt enlargement of which denotes the disappearance, deep below the ocean level, of all the older crystalline rocks, and the presence of the far more easily excavated strata of the uncemented and horizontal deposits of a tertiary or post-tertiary age.

Reviewing the phenomena of cleavage throughout this southern zone of the Primal rocks as they are revealed on the Susquehanna, we discover an interesting exception to the prevailing law of a south-eastward cleavage dip, attended, however, with no interruption to the universal law of the parallelism of the cleavage structure to axis planes of the flexures, or the direction in which the strata have been obliquely compressed.

First, The northern tract of the Primal slates exhibits over their whole breadth, from the limestone near Wrightsville to the limestone of Cabin Branch Run, the normal or south-eastward dip, and under conditions which imply at least two anticlinal folds with axis planes, dipping, of course, to the same quarter; and throughout this belt the cleavage fissures invariably dip at a steep angle in the same normal direction.

Secondly, The wider middle tract between the synclinal of the Cabin Branch Run and the anticlinal district of Shenck's Ferry, displays, with scarcely any interruption, an abnormal or north-west dip of the strata; but here the cleavage is nearly vertical, sometimes very steeply southward, but more prevailingly northward, or in the direction approximating to parallelism with the steep abnormally-dipping axis planes. This is the state of things from a little S. of Cabin Branch Run to the vicinity of Lockport, where the cleavage, previously fading, disappears.

Thirdly, Crossing the narrow belt of more open and visible anticlinal waves, between Shenck's and McCall's Ferries, we enter, above the latter locality, upon one great sequence of south-east dips of the strata, extending the whole way to the State line, and indeed to the southern limit of the metamorphic rocks at the mouth of the river. From McCall's Ferry to Slate Point the section presents us with a third zone of cleavage; but this observes invariably its normal direction, dipping to the S.E., and, as usual, at a steep angle. Below Slate Point, where the degree of metamorphism, even in the Primal slates, becomes once more excessive, the cleavage again vanishes, or gives place to that condition which is called foliation, and which does not permit, except in rare instances, the distinct recognition of the original lamination of the strata.

It would thus appear that even where the cleavage assumes an abnormal direction of dip, it is in obedience to an equally abnormal direction in the plication of the strata; and we may further remark, that wherever the rocks exhibit evidence of excessive metamorphism, or, in other words, show an approach to the maximum conditions of crystallisation or separate segregation of their constituent minerals, the cleavage ceases, and foliation, or that structure which is derived from the parallel arrangement of the component crystalline minerals, takes its place.

PRIMAL SERIES, OR SLATE-BELT IN THE SOUTHERN PART OF YORK COUNTY.

As already intimated, very little need be said in detail of the altered Primal slates S.W. of the Susquehanna in York County, no connected section being possible after leaving the bank of the river. Even on the line of the York and Baltimore Railroad, the natural and artificial sections of the rocks are infrequent, and so shallow that it is not possible to trace out the changes in the dip of the strata, detect their foldings, or recognise their lines of contact. As the Susquehanna section furnishes a far more complete exhibition of these, it will suffice to say of the western half of this slaty belt, that quitting the range of the synclinal limestone trough called the York Valley, and proceeding southward by the Codorus Creek and its South Branch, we cross nearly at right angles to the strike a wide succession of bluish-grey fine-grained micaceous and talcose slates intimately set with cleavage planes, the flakes of mica being invariably arranged upon the cleavage surfaces. Some bands of a very pale or whitish green tint are extremely silicious, with delicate micaceous and talcose partings, and are identical in aspect and composition with the highly-altered and shaly portions of the Primal white sandstone of the vicinity of the Schuylkill, for example, at Barren Hill. As far S. as the Hanover Junction, the apparent dip of the strata is steeply southward; though within this space there are indications, especially between the third and fourth mile-posts on the railroad, of an anticlinal flexure in the strata, broad and low, corresponding very nearly with one of the flexures in the same slate-belt at the river. The cleavage-dip likewise agrees with that at the Susquehanna, being everywhere southward at a high angle. These conditions imply one or more flexures of the prevailing character, steep or inverted on the north-west side, extending to the synclinal trough or little valley just S. of the Hanover Junction, which appears to be seated in the basin which embraces the limestone belts of Cabin Branch Run and of Jefferson. Passing S. of this natural boundary, we enter at once on a succession of exposures of micaceous slates, very similar to those traversed by the section further north, with the exception that they are more crystalline. These continue with a steep north dip as far as the village of Glen Rock. There the strata begin to assume a more highly metamorphic character, and lithologically would be called green quartzose micaceous gneiss, or gneissoid mica-slate, and they retain this crystalline type the whole way hence to the State line. It is worthy of note, that the northward dip seen in the district north of Glen Rock continues, with only local interruptions and trivial contortions, throughout the remaining part of the section. It is toward the central portion of this more gneissoid division, especially in the neighbourhood of the Shrewsbury Station, about three miles by railroad north of the State line, that the contortions or little flexures most predominate; and it is interesting to observe that these correspond very nearly in their latitude of transverse distance across the slate-belt, with those noticeable at the Susquehanna, in the vicinity of Otter Run. Another circumstance harmonising the two sections, is the absence of any distinctly-pronounced South-dipping cleavage after we pass the village of Glen Rock, but in place of this a wavy foliation seemingly coincident with the stratification. The section at the State line does not enter the belt of South-dipping stratification, with steeper South-dipping cleavage, which the Susquehanna Valley exposes from M'Call's Ferry southward the whole way to the serpentine belt at the State line.

Reviewing these facts of dip and structure, we find in this comparison of the two sections, a striking confirmation of the general principles of the relations of cleavage to the crust undulations so frequently enforced in this work. The whole topographical geology of southern Lancaster and York demonstrates a progressive sinking of the flexures, or anticlinal and synclinal waves, as they advance north-eastward to the Susquehanna, and across it to the limestone tracts of the Conestoga and Pequea, where the slates finally sink out of sight in flattening anticlinal spurs. Now it is in this district of subsidence, or at the Susquehanna, in the belt prolonged from Turkey Hill, that the cleavage-dip approximates to the perpendicular, leaning almost as often to the North as to the South, parallel to the *axis planes* of the flexures, many of which, as already intimated, observe a northward instead of a southward dip. Further towards the S.W., where the flexures are manifestly more closely compressed, and therefore more oblique, but where their axis planes, in place of dipping to the south-eastward, descend north-westward, contrary to the usual rule, the cleavage is less perpendicular and more constantly towards the same abnormal quarter.

In a rather wild and sequestered neighbourhood among the Barren Hills, thirteen miles S.E. from York, we come upon Susan Ann Furnace, not recently in operation, but undergoing repairs. The iron ore procured near it was found to make an inferior metal, and was abandoned for a purer variety obtained about seven miles to the W., at a point seven and a half miles S. of York, where the mineral occurs between seams of disintegrated slate, in nests and loose deposits. It is rather silicious, but is said to yield a tolerably good iron. Near the Maryland line, at Essex Hall, on the farm of Mr Clark, a small deposit of iron ore was worked some years ago. In the fields between this and the State line, are found loose crystals of red oxide of titanium.

CHIQUES RIDGE.

A broad and conspicuous chain of hills, known as Chiques Ridge, is the next principal belt of the Primal strata. It originates about three miles N.W. of Lancaster, and after ranging almost due northward for eight miles, crosses the Susquehanna a little above Columbia, and extends parallel with the southern side of the river, until it passes Codorus Creek, and is overlaid by the south-eastern edge of the Mesozoic red sandstone. This belt is in many parts more than one mile in breadth, and near its eastern extremity, where it is widest, it contains two or three anticlinal flexures.

The general structure of this ridge, as seen at the Susquehanna, is that of a very much compressed or folded anticlinal flexure, on the northern side of which the strata lie in an *inverted* altitude ; that is to say, the rocks, originally uppermost, are seen dipping apparently beneath others inferior to them in the order of stratification. The consequence is that the limestone lying N. of the ridge dips southward, to underlie the rocks of the ridge. Above the bridge at Wrightsville, the most southern member is a slaty sandstone evidently one of the upper strata. It dips 70° S. Approaching the main axis of the ridge, we meet high perpendicular cliffs, consisting of the Primal White Sandstone, and indurated Primal upper slates. The colour of the rock is whitish, sometimes of a bluish tinge. About a mile below the mouth of Codorus Creek, to the N. of the folded axis, the sandstone is underlaid by a tolerably thick belt of striped slates, this again by a succession of thick strata of sandstone and slate, the latter predominating, until we reach the limestone at New Holland. Sometimes the slates dip slightly N. from the axis, and sometimes they are *inverted*, or dip towards it. Half a mile above the furnace on Codorus Creek, the compact white sandstone dips N. 60°. From this to Brillinger's, we see no more of the sandstone, the rock being the upper silicious slate similar to that at the mouth of the Codorus. The belt of white sandstone terminates westward at a point at about two miles N.E. of York, where the Codorus flows round it. The belt of silicious slate, lying further N., passes westward from the mouth of the Codorus and New Holland, ranging S. of Liverpool, until it is covered by the red sandstone at Shultz's, four miles north of York.

At Chiques, on the Susquehanna, we have a very distinct and bold exposure of nearly all the Primal strata of this belt, as shown in the enlarged section.

SECTION FROM COLUMBIA TO THE CHIQUESALUNGA CREEK AT HALDEMAN'S, THROUGH THE CHIQUES RIDGE.

This fine natural section gives us a view of the whole constitution and structure of the Chiques Ridge. By it we learn the precise conditions into which the strata have been altered by igneous agency. The rocks embraced here are in the descending order, or that in which, looking eastward, we shall review them.

1. The alternating or passage beds of slate and limestone, connecting the bottom of the great Auroral limestone series with the top of the Primal; 2. The Primal newer or upper slates ; and, 3. The Primal White Sandstones.

1. The alternating group extends from the town of Columbia, past the railroad engine-house to the furnace. Between the street at the engine-house and the furnace, a distance of about 1100 feet, we cross two thick bands of the limestone and an interposed bed of slate, all dipping at an average angle of 50° to the S.S.E. The first bed of limestone, magnesian in its composition, is exposed for a little more than 250 feet in the bank. It is

very crystalline, mottled, and partially intersected with steep South-dipping cleavage fissures, and altogether exhibits evidence of much metamorphism; indeed, the cleavage in places renders the recognition of the bedding quite obscure.

The band of slate, also about 250 feet across, is of a dull olive-colour, very ferruginous, highly indurated, and intimately cleft with cleavage-joints. These dip about 75° southward, or steeper than the strata do; nor do they coincide in strike with the bedding, but range more E. and W.

Passing the slate, the last or lowest band of the limestone is seen exposed for about 400 feet. This is also highly magnesian, but more sandy than the other bed. It is quite as highly altered, being crystalline, white and mottled, and full of cleavage.

2. From the furnace to the first exposure of the Primal sandstone, a little north of the second ravine, there is a fine natural section of the whole thickness of the Primal upper slate, though very possibly a folded flexure near the Tunnel may repeat a portion of the beds under three parallel dips. The apparent dip is monoclinal until we pass the second ravine, where a low narrow anticlinal wave is discernible. If we assume no fold or repetition of the strata between the furnace and the ravine, a distance of 2500 feet, and accept 45° as the average dip of the beds, we must suppose the thickness of this upper Primal slate to exceed 1800 feet; a bulk far exceeding that which it possesses further eastward in the North Valley Hill of Lancaster and Chester.

This slate appears to be even more transformed in its texture by igneous action than the beds above it. It is very hard, internally of an olive green, externally of a dingy brown, from presence of much oxide of iron, and has a baked aspect. It exhibits, moreover, in every part of the mass, an excessive amount of the cleavage fissures. These dip in all cases southward, and at angles varying from 80° to 65°, declining as we go northward towards the anticlinal flexure in the underlying Primal sandstone, with the axis plane of which those most adjacent are almost strictly parallel. Even in the low small arch N. of the second ravine, the cleavage planes are true to this law of parallelism, unaffected by any tendency to the fan-tail arrangement which such an arch would have induced had it been more remote from the overpowering influence of a great folded flexure.

3. Passing the base of the upper Primal slate, we cross next an irregular oblique arch or anticlinal fold of the Primal sandstone, occupying a width of about 500 feet. The southern flank of this arch contains two gentle waves; the northern is completely inverted, so that the sandstone beyond the axis dips almost parallel with that south of it. Between these two similarly inclined legs of the curve, a mass of slate, about 150 feet across its strike, displays itself in the very axis of the flexure. This is manifestly the uppermost bed of slate of the Primal sandstone group; this formation here containing as its chief members two white sandstones, and an interposed bed of slate about 300 feet in thickness. Between the anticlinal axis, lifting this middle slate to view, and the northern base of the Chiques Ridge at Haldeman's, a distance of nearly 3000 feet, occur three other exposures of the Primal white sandstones: the first of these is some 250 feet above the Henry Clay Iron-Furnace; it is the same sandstone as that of the compressed anticlinal just passed over, here brought again to the surface with a southern dip of 60°. Between it and the anticlinal fold there is therefore an oblique compressed basin of the lower members of the upper Primal slate, at least such is a reasonable construction of the strata as they are seen. The slates embraced in this supposed synclinal trough show the slaty cleavage dipping 70° to S., 20° E.; whereas the planes of stratification dip at 60° to S., 10° E., a deviation in strike of 10°.

This upper sandstone of the Primal sandstone group has, at its outcrop N. of Henry Clay Furnace, a thickness of about 27 feet.

The slate, or middle member of the same group, about 300 feet thick, as already stated, next rises, leaning southward at an angle of 50°, and immediately beyond it there appears the upper portion of the lower or main Primal white sandstone, most curiously doubled into a beautifully-rounded oblique saddle, the north side of which is perpendicular, the south dipping at 50°. It rises above the level of the road about 20 feet, and consists wholly of the white silicious sandstone, without joint or fracture, or trace of cleavage fissure, and with the lines of original bedding only barely discernible. Here the pure massive sandstone has undergone a most excessive, yet regular folding, or doubling together, at a time when the materials must have been in a partially movable or semi-plastic state. It is one of the most striking instances visible within the whole Appalachian Chain, of this plasticity of the sedimentary matter of the ancient Palæozoic strata. The slaty mass overlying this much bent and compressed sandstone, has been doubled into a much more acute curve at the anticlinal axis, and is, moreover, greatly cut in the sharp synclinal fold, just N. of the anticlinal, by cleavage-joints. Indeed, all the beds from this middle anticlinal sandstone to the third or northern one, are pervaded with the cleavage fissures: those in the slate, separated by very short intervals; those in the beds of sandstone occurring at an average distance of about half an inch.

Approaching the third anticlinal, or that of the main northern crest of the ridge, we meet the lower or chief member of the Primal white sandstone group, elevated in a grand waving arch, forming a superb mass of cliffs south of and behind the mansion of Professor Haldeman. Facing the ends of these strata, which span in all a distance of about 1000 feet, we discover that the sandstone exhibits, when closely scrutinised, not a symmetrical, normal wave, but one containing two synclinal curves upon its crest. The southern flank of the general wave dips southward at a gentle angle, increasing from 30° to 45°. The northern flank plunges from the last rapid turn, almost perpendicularly out of sight, to fold most probably backwards beneath the arch, and finally to abut, with dislocation, at a depth of 2000 feet or more against the south-dipping limestones visible just beyond it in the stream.

In this main terminal arch the cleavage, which elsewhere dips invariably southward, deviates from this prevailing rule at one point on the S. slope of the wave, and dips at a steep angle northward. Elsewhere throughout the flexure it slants southward at an angle of 80°.

The thickness of the lower sandstone member cannot be accurately estimated, but, including its thin beds of slate, we may assume it at not less than 300 feet. The fault or dislocation alluded to evidently extends a great distance E. and W. along the northern base of the Chiques Ridge. Some of the beds of the middle and lower members of the Primal white sandstone exhibit, in the Chiques Ridge, a great multitude of specimens of the stemlike fossil, the *Scolithus linearis.* This is nearly straight, and would seem to have a small knob or swelling at one of its terminations. Its position in the rock is invariably perpendicular to the plane of the beds, and therefore where cleavage disguises the direction it is a good guide.

Pigeon Hills.—About eight miles south-westward from York there occurs the range called the Pigeon Hills, rising through the limestone of the York Valley. These hills have an elliptical form, are between seven and eight miles long and three broad, terminating south-westward near the turnpike, at a point four miles north of Hanover. The strata comprising different portions of the Primal sandstone and Primal newer slate, consist usually of a dark slate and a light-coloured sandstone, of different degrees of fineness and compactness. The whole belt, though carefully explored, develops little of interest in a scientific or an economical point of view. About four miles N.N.E. from Hanover, occur *green chlorite,* and a beautiful variety of *foliated oxide of iron.* The slate in the neighbourhood shows small traces of *copper ore.* A belief exists throughout this neighbourhood that the slates of these hills are of the coal formation, and that coal perhaps exists in them, whereas they belong to the very lowest fossiliferous formation of our State; while the workable coal is exclusively confined to a wholly different group of rocks, lying much higher in the order of stratification, and occupying an entirely different geographical range.

The junction of the slate and limestone rocks is seen on the S. of the Pigeon Hills, about four and a half miles N.E. from Hanover.

CHAPTER IV.

PRIMAL ROCKS OF THE SOUTH MOUNTAINS BETWEEN THE DELAWARE AND SCHUYLKILL.

That the Primal series is not continuous in the belt of the South Mountains, where they traverse Northampton and Lehigh, is rendered highly probable by the infrequent and local manner in which it shows itself. Still we are entitled to consider it as not confined merely to the few scattered points where it emerges to the day, but as resting in many places at the base of the Gneissic ridges, buried under a deep covering of loose Diluvium. I shall hereafter refer to various places where it rises to the surface in sketching the limits of the limestone, which, whenever it is present, it immediately underlies. There are many exposures in this part of the chain where the limestone is seen resting directly in contact with the gneiss. At the Delaware the Primal sandstone flanks the gneiss in the Lehigh Hill, and also near Durham. Going westward, it shows itself on Durham Creek, a little E. of Springtown, in the ridge bounding the limestone E. of Hellertown, and in the end of the spur immediately E. of the South Branch of the Saucon. Ascending the Lehigh, the first point where it appears in place is on the south side of the river about a mile S. of the Bethlehem Bridge, where it occurs in a thin band, resting on the gneiss, and dipping northward 20°. It runs in a narrow belt from the road eastward to the Saucon, where it adjoins the lower termination of the limestone of that stream. The sandstone occurs on the northern slope of the small ridge of gneiss rocks occupying the north side of the Lehigh, E. of Allentown. It shows itself again not far from this, on the southern side of the river, about a mile below the Allentown Bridge, the piers of which have been constructed of it. Here it constitutes but a thin stratum, the limestone in some places lying nearly in contact with the gneiss. There are but two other localities in Lehigh and Northampton counties. The first of these is near the top of the mountain E. of Emaus, where a rather coarse variety of the sandstone is seen dipping with the slope of the mountain, rather steeply towards the W.N.W. The mountain itself is Gneiss. The other locality is at Millerstown, and exhibits the sandstone as a low ledge at the foot of the mountain, dipping 10° towards a point 75° W. of N. Westward of this, especially in Berks, it increases in thickness and abundance as we approach the Schuylkill.

In *Berks County* the white sandstone, which appears in a few detached localities along the north-western line of the South Mountains in Lehigh County, begins to show itself as a more continuous formation, rising even into high irregular ridges in the south-western part of the chain. A very usual position of the sandstone is upon the flanks and around the extremities of the spurs of the gneiss, where it often indeed overtops the crystalline rocks, which then appear only on the crest of the hills as low dykes difficult to trace. Even where the sandstone is best developed, some difficulty attends our tracing it as a continuous formation. This arises from its immediate proximity to the greatly-convulsed gneissic strata, and from its lying so frequently on the declivities of the hills, where its outcrop is much obscured by fallen fragments. The sandstone, where it is subordinate to a larger ridge, often either encircles, at a little distance, the extremity of the spur, or lies more or less obliquely across it. Sometimes, even in the middle of a high track of the sandstone, where no regular belt of older rock protrudes itself, evidence is perceived that this has reached the surface at certain spots, from the quantity of angular fragments. The sandstone itself offers often great difficulty in determining its stratification and the true direction of its dip; whole hills looking like mere piles of huge angular blocks, innumerable fissures and cleavage-joints traversing the beds so as greatly to perplex the observer.

Passing from Lehigh into Berks, the first exposure of the sandstone is at a hill lying S. of the Little Lehigh, and about two miles S.E. of Metztown. Here the rock is chiefly in loose pieces, covering the foot and lower declivity of the hill. The sandstone also shows itself in place, about one mile S. of Metztown, immediately W. of the church. Between the visible edge of the limestone, which passes by Metztown and the foot of the hills further S., there is a considerable tract of country where no rock appears upon the surface, with the exception of the isolated tract of sandstone at the church just referred to; a deep covering of diluvium hiding everything from view. Approaching the mountains from the N., the first rock seen in place is a white variety of gneiss. This is on the road leading to Hoof's Inn. West of this, in Maxatawny Township, the limestone is seen where a road crosses the Sacony Creek. The sandstone, which shows itself N.E. of the creek, disappears a little S. of Grim's Mill, the gneiss showing itself on the W. side of the stream, between the mill and Hunter's Furnace.

The general margin of the limestone passes about a quarter of a mile N. of Walnut-town. About a mile south of this place, to the N.E. of the road, occurs a sandstone ridge, running in a N.E. direction. A little further S., upon the same road, we observe the outcrop of the gneiss. This gneiss, part of a long belt, averaging about a mile in breadth, terminates at Miller's Mill on Dry Run. A belt of the sandstone, as already described, flanks it both upon the N. and S., the sandstone uniting round the point of the gneiss, a little east of Solomon's Temple. Southward from this last-mentioned place, towards Reading, the sandstone lies on the E. of the road the whole way to within three miles of the town, where a belt of slate, the upper member of the Primal series, crosses the road. If we here turn aside to the N.E., taking the road to Barnard's Mill (Rothermel's Mill on the county map), we encounter, just at the mill, a low protruding mass of igneous rocks. A little to the N.W. of this point, a small body of limestone has been discovered, S. of which, in the sandstone, we may trace a low dyke of syenitic rocks running towards the N.E. E. of its north-eastern end, and W. of its south-western, occur two other small patches of limestone. The line dividing the limestone of the Schuylkill Valley from the sandstone and slate bounding it on the E., after following the road which leads from Solomon's Temple south, suddenly curves to the eastward about two miles north of Reading, reaching, but not crossing, the road from that city to Pricetown. Here, at Rothinberger's Inn, turning very abruptly to the S.W., and gradually receding westward from the road last mentioned, it next runs to the Schuylkill, passing through the western side of Reading, leaving thus a triangular tract of the limestone included in the general area of the sandstone.

Hills East of Reading.—Penn's Mountain, commencing E. of Reading, and running in a N.N.E. direction nearly five miles, consists, on its summit and western side, of the Primal white sandstone, dipping to the W.N.W. Descending the eastern slope of the mountain, we soon encounter the gneiss rocks, which maintain this position as far to the S.W. as Kesler's Mineral Spring. This is the termination of the wide belt of gneiss and syenite, coming off from the general chain with a prevailing south-west and north-east direction of the strata. At Spie's Church there occurs a high sandstone ridge in the midst of the gneiss, being detached from any other tract. Penn's Mountain, at its northern extremity, sweeps suddenly to the eastward, jutting between the main belt of the gneiss around Spie's Church, and a narrower tract which crosses the Reading and Pricetown road. N. of this last tract, and N.W. of the prolongation of Penn's Mountain, are some high sandstone ridges, probably concealing dykes or beds of crystalline rocks between them. Pursuing the road north-eastward to Miller's Inn, we have the sandstone on the N.W., while on the S.E. the hills consist principally of gneiss. Between Miller's Inn and Pricetown the road separates a hill of gneiss on the S.E. from a high short ridge of sandstone on the N.W. Gneiss occurs also about one mile from Pricetown, south-east of the road going towards Sterner's Inn (of the old State map). A sandstone ridge rises at Sterner's Inn, on the north-west side of the road, and extends nearly to the tributary of Manatawny Creek, in Rockland Township, beyond which, until we pass Roth's Mill, all the rocks are crystalline. Going E. of S. from Roth's Mill to Pine Creek, we encounter none but gneissic rocks forming a wide tract. The sandstone, however, shows itself at the spot marked Shiffert's Inn on the county map, appearing on the slope of the hill N. of the road. The rock here is somewhat coarse and of a purplish colour. Passing to the S.W. it seems to cross the road. Descending the creek we meet another ridge of similar sandstone, occupying the west side of the stream, at a mill designated on the Map as Mineder's. Further S., about a quarter of a mile N. of Snyder's Upper Forge (Udree's Forge of the old map), the sandstone again shows itself on a small hill E. of the creek, and again on its W. side.

The hill immediately to the S.E. of Sterner's Inn consists obviously of gneiss, the surface being wholly covered with their fragments, though no regular outcrop is seen. Still pursuing the road to Oley Furnace, we pass diluvium, containing much fragmentary sandstone, until at the creek, close to the furnace, we behold the sandstone in place, dipping steeply on the east side of the stream to the N.N.W. The rock here is coarse and reddish, and occasionally very talcose. Immediately W. of the creek lies a large hill of syenite, and about half a mile nearer Fredensburg, we come upon the margin of a wide tract of slate, apparently the upper member of our Primal series, of which the sandstone hitherto most commonly encountered is the lower. Nearly two miles N.W. from Fredensburg, on the north-east side of the road to Miller's Inn, occurs a belt of sandstone, dipping steeply to the N.N.W. Here is an old mine of iron ore to be described hereafter. Beyond this a sandstone ridge is seen running parallel with the road, about a quarter of a mile on its north-east side. Between this and Miller's Inn, an interval of about a mile, the prevailing rock is gneiss.

Let us now trace the line which divides the gneiss from the Primal slate and sandstone, and the Auroral limestone in the northern and western parts of Oley Township. About three-fourths of a mile S.W. of Lobach's Mill, on Pine Creek, we come upon the margin of the limestone, crossing the stream in an eastern and western direction, through the lands of Jacob Keim. The dip here is due S. 60°. To the N.E. and E. of this the sandstone shows itself in a belt, to be presently described. North of St Peter's Mill (marked Maul's on the old map) runs the edge of the gneiss, which here exhibits no sandstone interposed between it and the limestone. The margin of the limestone is well seen half a mile W.S.W. of the mill, the rock dipping steeply to the S.S.E. Immediately above this limestone, on the creek, we have the slate crossing the stream just at the road leading to Sterner's Inn. The true dip of this last rock is difficult to discover, owing to the obscurity of the divisional lines of the strata, and the abundance of cleavage planes, wholly independent of the lines which mark the dip, the dubious direction of which leads to some uncertainty respecting the precise formation to which the stratum belongs. Could its beds be seen passing unequivocally under those of the limestone, it would plainly prove itself to be the Primal newer slate; if, on the other hand, it should be seen to dip away from the limestone at the line of contact, no doubt would remain as to its being part of the Matinal slates. The margin separating the slate from the gneiss passes about half a mile N.W. of Fredensburg. Taking the road leading out of Fredensburg to the S.W., we pass over the slate for nearly a mile and a half, until we cross a little stream, the dividing-line of Alsace and Oley townships, where we pass directly upon the gneiss. Ascending the creek by a steep ravine, we pass the eastern termination of the spur of sandstone at Spie's Church, already spoken of. East of this spot the boundary of the slate and gneiss is near Knabb's Mill (Reiff's on the old map). The hills immediately W. of the mill (marked Knabb's on the map), and of the road separating Oley and Exeter townships, are strewed with fragments of gneiss, as far down the creek as the first exposure of the limestone, which is half a mile north of the road running westward from Oley Forge. Following this road, which deflects towards the S.W., we pass across a corner of the limestone tract, and at a short distance W. of the Manokesy Creek encounter the common margin of the limestone and the gneiss. These two formations rest apparently in contact, from the upper point of the limestone, on the Manokesy, below the mill marked Knabb's, throughout a mile and a half towards the S.W.

About two miles E. of Maurer's Inn, the sandstone shows itself in place, between the limestone and the gneiss, on the southern slope of a hill, some distance N. of the church. Under this sandstone is an argillaceous slate, probably the Primal older slate, in very thin laminæ. Between this and Maurer's Inn the rock is exclusively sandstone, the large double hill N.E. of the tavern being entirely of this formation. Here a quarry has been established for getting building-stone; the dip of the rock is obscure. This ridge of sandstone extends in a north-easterly direction, about two miles and a half towards the insulated sandstone hill, near Spie's Church, from which, however, it is separated by more than a mile of gneiss. East of the ridge the rocks are a white variety of gneiss, consisting of quartz and decomposing felspar, and a syenite composed of felspar and hornblende, in frequent alternation with the gneiss. Where these rocks abound the surface is marked by small rounded hills, covered with fertile soil, giving a pleasing aspect to the country. A similar topography is particularly striking in some parts of Colebrookdale Township, hereafter to be mentioned.

The limestone belt, bounded, as we have already said, for the first mile and a half by gneiss, runs afterwards the whole way to the Schuylkill, below Reading, crossing Bishop's Creek about a mile below Maurer's Inn, and folding round the southern point of the Neversink Hill. From the Manokesy, westward to the Schuylkill, the limestone belt, bordered on the S. by the middle secondary rocks, contracts into a narrow zone, a few hundred yards in breadth. On its narrow limit it dips to the S. Where it crosses the Perkiomen turnpike, three miles from Reading, it shows in a quarry near the road many beds of a crystalline granular structure. Much of the rock at this place is of a dull yellowish white. It dips a little W. of S. It strikes the western reach of the Schuylkill, about a mile and three-fourths S. of Reading, where it is overlapped on the S. by the coarse calcareous conglomerate of the Middle Secondary series. North-eastward this narrow belt opens into the wide tract of limestone, which occupies much of the eastern half of Oley Township. From its southern point on Manatawny Creek, a fourth of a mile below the line dividing Amity from Earl townships, the eastern edge of this large tract passes up the Manatawny, and then up its eastern tributary, as high as the line which separates Oley from Pike. Its northern margin crosses Pine Creek, about a mile below Lobach's Mill. Its north-western corner is at the place marked on the map, Peter's Red Ochre Mine. Its western limit is the eastern boundary of the slate, which occupies a large tract in the western half of Oley. The limit between these rocks runs southward, nearly through the middle of the township, until it strikes the Exeter line a little E. of Manokesy Creek.

The slate, which we have already mentioned to be most probably the Primal newer slate, spreading from the western edge of the township (Oley), eastward beyond Kemp's Inn, shows generally a dip to the S.S.E. About half a mile S. of Kemp's Tavern the slate is bordered by slaty limestone, which apparently overlies it. The slate E. of Fredensburg graduates into slaty sandstone; but S. of Rieff's Mill the slate is soft and sectile, approaching in texture to pipe-clay. At this and several other places its strata are intersected by veins of quartz.

I have already referred to the belt of sandstone which occupies the valley of Pine Creek. This extends from the neighbourhood of Pott's Forge to the edge of the limestone, a mile below Lobach's Mill, where, doubling round the point of a wide spur of the gneiss, it runs eastward, to join the much longer tract of sandstone which follows the Manatawny and its eastern tributary in Pike Township, for many miles. This latter range of the sandstone, commencing near the western corner of Hereford Township, crosses the narrow part of District Township, and then the whole of Pike, following the eastern side of the Manatawny nearly as far down as the line dividing Amity and Earl.

Mention has already been made of another tract of sandstone in the form of a ridge or spur, commencing about a mile E. of Spang's Furnace, and running in a N.E. direction into the region occupied by the gneiss. At Hill's Inn the limestone is found on the E. side of the Manatawny, dipping to the N.W. The sandstone immediately E. of this dips steeply in the same direction. A little N. of the Amity Township line, the sandstone, on the other hand, crosses to the west side of the creek. At the bridge on the Township Road, over the Manatawny Creek, the limestone, in its upper beds, is striped by reddish ribbons. A calcareous slaty sandstone here occurs, precisely similar in appearance to the red sandstone of the Middle Secondary or Mesozoic rocks, of which it may be a detached or outlying patch. About a quarter of a mile below this, on the creek, is the general margin of the Middle Secondary red shale and calcareous conglomerate.

The southern half of Earl Township includes chiefly long hills of syenite and other crystalline rocks, running in a N.N.E. and S.S.W. direction, having coarse Primal sandstone flanking them on their north-west slopes. Taking the road from Kline's Tavern, near the Manatawny, eastward to Boyerstown, the sandstone of one of these spurs, approaching from the N.E., shows itself on the road dipping 35° S.S.E. At the intersection of the road and the township line of Earl and Douglas, we enter on the margin of a small tract of limestone, overlapped further S. by the red sandstone. It crosses to the N. of this road. The limestone peeps out at a house laid down on the county map as Keely's Tavern, and shows itself again in a quarry a few hundred yards E. of the tavern kept by Mr Gresh. Near Keely's Old Stand the sandstone occurs on the N. side of the road, and it again appears N.W. of Gresh's. The limestone to the S. of this is overlapped by the Middle Secondary rocks. East of the limestone, and before reaching Rhoads's Mill, we come, in succession, upon white gneiss, syenite, sandstone, and limestone, the latter appearing at the mill. From this point eastward to Boyerstown, the whole space is occupied by crystalline rocks, covered on their Southern margin by the Middle Secondary.

All that part of Colebrookdale Township lying to the N.W., N., and N.E. of Boyerstown consists exclusively of gneiss. This forms innumerable hills, covered by a deep and rather fertile soil, the whole district presenting, in a succession of undulating outlines, a highly pleasing series of landscapes. The limit of the gneiss and overlapping Middle Secondary sandstone, passing through this township, from Rhoads's to the West Branch of Perkiomen Creek, I have already defined.

A locality of crystalline limestone occurs in the centre of Colebrookdale Township, on the North-east side of a road. The spot is about three-fourths of a mile N.W. of the edge of the Middle Secondary red sandstone. Between this place and Swamp Creek lie several high hills, covered entirely with diluvium and fragments of sandstone. Hills of this description are common along the line separating the Middle Secondary region from the gneiss of the South Mountains. At Swamp Creek we enter a valley bounded on the N.W. by rounded knolls of the gneiss, and on the S.E. by the Mesozoic red sandstone. This valley contains several exposures of limestone. The first of these is on the West side of the stream, and belongs to Peter Motha. A little N.E. is the quarry of Jacob Oberholz, and beyond this, in the same direction, the limestone occurs on the premises of Henry Stauffer. At the first place the strata dip N.E.; at the second, nearly S.

A narrow belt of the Primal white sandstone commences just E. of the West Branch of Perkiomen Creek, and runs to the N.N.E., through Hereford Township, to the line of Lehigh County. It is bounded on the S.E. by the overlapping red sandstone, and on the N.W. by the gneiss. The white sandstone shows itself on the main road, passing through the centre of the township; the rock dips towards the S. It is again well exposed on the East side of the main Perkiomen Creek, where the Sumneytown road crosses.

We find a small insulated patch of the white sandstone in District Township, about a mile and a quarter N.W. of Hoof's Inn, where it occurs surrounded by an elevated table-land of gneiss rocks; the sandstone is of a coarse texture. Passing from Hoof's Inn south-westward along the West Branch of the Perkiomen, we meet another spot where the sandstone undoubtedly exists in place; this is about half a mile from the inn, on the S.E. side of the road. A little W. of this commences on the stream a narrow valley, extending down to John Rush's forge, where the mountains approaching close it in. The Old Mount Pleasant forges are situated near the lower end of this valley. Limestone shows itself a short distance above Rush's Mill (Hunter's on the old State Map), dipping S.S.W. It is again exposed in two fine quarries, one on each side of the creek, at David Schall's forge (Thompson's on the old Map). In the more western of these quarries the limestone considered the best is of a dark-blue colour. According to our analysis, the rock in both localities is highly magnesian, the composition being in other respects also precisely similar; the lighter-coloured variety containing, if anything, rather less foreign matter. The dip in both quarries is to the N.W.

Iron Ores of the Primal Strata.—Before closing this description of the Primal rocks of the State, it is expedient to mention that large deposits of brown hæmatitic iron-ore are not unfrequent in the soil and detrital matter which rest upon the Primal newer slates. This is the geological position of the great mine on Chestnut Hill, four miles east of Columbia, the ore occurring in a sort of basin of the disintegrated slate. Throughout the Appalachian Chain much valuable iron-ore is discovered in connection with the same formation. The localities of these Primal ores of iron will be discussed in the general Chapter upon the Iron Ores.

OUTLYING BELT OF PRIMAL ROCKS OF MILLBOUGH HILL.

There is an insulated belt of the Primal strata skirting the Northern side of the solitary oval tract of gneissic rocks W. of Reading and S. of Womelsdorf, which appears to extend from a point nearly S. of Sinking Spring westward, a little N. to the county line of Berks and Lebanon, thence south-westward, terminating in the western spurs of Millbough Hill, N.E. of Shefferstown. It is narrow when intersected by Cacoosing Creek, but broad near its western termination, from the presence of two or three anticlinal flexures. The strata consist of both the Primal slates and Primal white sandstone, fragments of which rocks are strewn abundantly in many places along the base of the ridge, hiding the southern edge of the limestone of the Great Valley.

CHAPTER V.

SOUTH MOUNTAINS, SOUTH-WEST OF THE SUSQUEHANNA.

The irregular chain of hills west of the Susquehanna River in Adams, Cumberland, and Franklin counties, called the South Mountains, is a broad zone of low ridges, consisting almost exclusively of the Primal strata. It is the North-eastern termination of the first continuous mountain-range of the southern Atlantic States, called in Maryland and Virginia the "Blue Ridge." Tracing it South-westward, this tract originates near Dillstown in a narrow point, expands rapidly towards the head-waters of the Conecocheague, beyond which it grows narrower again, and curves swiftly Southward. It has the Cumberland Limestone Valley for its Northern and Western boundary, and the red sandstone plain of Adams County for its South-eastern; Green Ridge and Jack's Mountain on the Western border of Adams County are eminences in this hilly belt.

In its geological constitution this tract is without much variety, for it contains scarcely any rocks except those of the Primal series. It is doubtful if the true Gneissic rocks anywhere reach the surface within its borders, and only in one or two localities have even the lowest members of the Auroral limestone been met with covering the upper Primal slates. Even of intrusive igneous rocks it embraces a singularly small amount, those met with being chiefly greenstone and trap-rock.

The geological structure, or mode of stratification of this belt, is equally simple. The whole tract consists of two or three groups of high, narrow, nearly parallel anticlinal ridges, expanding and subdividing toward the S.W. These are composed of the Primal white sandstone. Between them are high parallel valleys and plateaus of the Primal upper slates, which, from being softer and more fissile, have been worn and trenched by the ploughing force of waters to somewhat lower levels than the more resisting, better cemented sandstones. The crests of the ridges are therefore stony and rugged, their flanks usually smoother, being formed chiefly of the slate.

To trace somewhat more in detail the several leading subdivisions of the belt, the first, or most eastern, is an anticlinal ridge, the rising of which N. of Dillsburgh, forms the very commencement of the chain. Commencing there, close to the Yellow Breeches Creek, which for many miles flows near its Northern base, it rises and expands until nearly opposite Shippensburg, where, already divided into two anticlinal prongs, it begins to subside, and finally sinks to the level of the Limestone Valley, about five miles E. of Chambersburg. A rather deep valley, that of Mountain Creek, follows this sandstone range on its South side, the whole distance out to the Cumberland Valley. It consists of the Primal upper slates, much intersected with slaty cleavage. At one locality, Pine Grove Furnace, there occurs in the middle of this range of slate a narrow band of limestone, marking the position of the synclinal axis, or keel of the trough, into which the formations have here been folded.

To the S.E. of this slate valley of Mountain Creek there is a second long continuous range of the Primal sandstone, commencing to the S.W. of Dillstown, and running forward, with little interruption, towards the State line, ending in a series of spurs N.E. and E. of Waynesburg. For some few miles from its point of origin, this hilly tract appears to include but one anticlinal flexure, and it probably continues of this simple structure to within three or four miles of the Gettysburg and Chambersburg turnpike road ; but further S. it spreads, takes in a second, and then a third wave, subdividing into separate anticlinal ridges, until three of these branch off in succession, and die away in prongs projecting into the limestone of the Waynesburg Valley. A fourth, called Green Ridge, runs more continuously forward, with one or two hitches in its course, until it is intersected by the State line.

The North-eastern termination of the mountain, near Dillsburg, consists entirely of the lower sandstone, the altered slaty belt on the Southern side having disappeared between the Petersburg and Carlisle turnpike and the end of the mountain, in consequence of the subsiding of the axis of elevation. It ends in two principal ridges. In a rough valley between these occurs a yellow porous sandstone, often indicative of *iron ore*, some of which was found on the surface near the end of the Southern ridge. A little N. of Dillsburg the limestone of the Cumberland Valley folds round the Eastern end of the mountain, and appears on Dogwood Run, S. of Yellow Breeches Creek, where it is covered by the overlapping rocks of the Middle Secondary series, consisting here of the calcareous pudding-stone, or Potomac marble, and altered red shale and red sandstone.

Another section across the mountain, more to the S.W., extends from S. to N. along the Baltimore and Carlisle turnpike. The first important stratum of the hills is the usual grey silicious altered rock so common along their Southern side. North of this, about three miles from Petersburg, occurs the dark green slate, with its epidote and white intrusive quartz. Succeeding this is an extremely compact silicious altered slate ; and beyond this, a reddish grey rock, of the same series, containing specks of reddish felspar and small veins of epidote ; and near this the fissile talcose rock, several times mentioned before. North of these we pass a tract of low ground, and then a high rough ridge of sandstone, ascending which we come to Mountain Creek, at Holly Furnace, not now in operation. Beyond this to the N. is another bold ridge, the northernmost of the chain, consisting also of the Primal white sandstone of the lower division, which here resembles closely the same rock as it occurs in Chiques Ridge, on the Susquehanna. The beds here have a steep southern dip of about 70°. This dip is evidently, however, an *inverted* one, as these are the *lower* rocks of the formation, and lie N. of a folded anticlinal axis. Between the Northern base of this ridge and the margin of the limestone of the Cumberland Valley, a deep deposit of diluvial matter hides from our view nearly the whole of the slaty or upper division of the Primal rocks ; which, in consequence of its easy denudation, is commonly found in the valley at the foot of the mountain, thus covered by transported matter.

Crossing the mountain by another section still further to the S.W., we find the following order of things. Beginning at Cumberland Furnace, and passing to the head-waters of Opossum Creek, the North-western ridges of the mountain, near Cumberland Furnace, consist entirely of the Primal white sandstone. In the ridge N. of Pine Grove the rock is a more talcose sandstone, belonging probably to a higher part of the formation. Large veins of white quartz are here abundant. A whitish talcose slate rests conformably upon the talcose sandstone, dipping with it to the S.E. This latter rock forms an admirable material for the in-walls of a furnace, and is used in that at Pine Grove. Immediately S. of Mountain Creek, near the furnace, occurs a thin interposed belt of limestone, used as a flux, and also taken across the mountain, into Adams County, for lime for the fields. This rock contains disseminated crystals of Fluor-spar.

Associated with this limestone is a valuable deposit of *iron ore*, which has supplied the furnace here for a long time. It is of the kind usually found in our limestone soils, being technically the *brown hydrated peroxide*, having a variety of structures. The *analyses* to be given will display the composition of one variety of the ore of this mine.

The limestone is evidently one of the beds at the alternation of the Primal slate and Auroral limestone. Passing the low ridge containing the limestone, we encounter a bold mountain of a somewhat talcose sandstone, two miles in breadth, containing probably an axis of elevation with the rocks on its Northern side *inverted.* On the Southern flank of this ridge occurs a belt of altered silicious rock, including a narrow band of talcose slate; and S. of this, a zone of green altered slates, charged with epidote and quartz; and overlying this again, another belt, of a more silicious altered slate. It is interesting to observe the importance which a single belt of limestone will give to a locality. It has here given rise to a rich deposit of *iron ore*, rendering productive a most beautiful and sequestered spot in a chain of hills, elsewhere remarkable for their forbidding features and sterile soil. The calcareous rock is only developed to any extent near the furnace, though it is said to be visible at Dull's Saw Mill, three miles higher up Mountain Creek.

A fourth traverse of the chain by the line of the Chambersburg and Gettysburg turnpike road, displays the following succession of outcrops and exposures of the rocks, and though these are not sufficiently connected to afford data for a structural section, they furnish some instruction as to the materials of which the tract is composed.

Leaving the limestone near Fayetteville, and going Eastward across the belt, we meet for the first three miles only fragmentary matter, chiefly of the white Primal sandstone, fine-grained, and weathering flesh colour and yellow, swept down from the hill-sides. Approaching Steven's and Paxton's furnace the prevailing rock is a conglomerate, with pebbles of the size of a pea. The rock becomes finer-grained E. of the furnace, and assumes more the typical characters of the formation. Passing Græffenburg Springs, a little E. of the furnace and the Toll-gate, we encounter the first clear exposure of Primal white sandstone, here in the condition of a bluish conglomerate with pebbles, ranging in size from that of a pea to that occasionally of a large nut. At this spot the strata dip 60° to S. 60° E. A little further on there is a second exposure, where the dip is more uncertain, but where the cleavage is distinctly 80° to N.W.; the apparent dip is 35° to the same quarter; the rock is a fine-grained sandstone. Fragments of the coarse bluish conglomerate are next met with, and still further on, in a shallow pit, one may see the Primal slates full of micaceous and talcose partings of a pale sea-green colour; here the strata dip 85° to N. 30° W., and the cleavage planes 75° to S. 10° E.

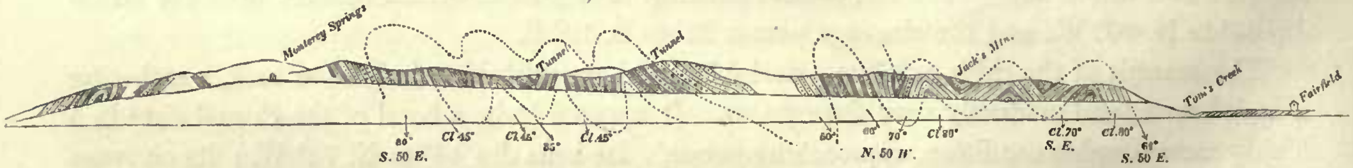
The summit of the ridge exhibits a dark-blue and greenish-blue indurated rock, weathering a dark brown, and evidently very ferruginous. It appears to be a band of the Primal slate in a highly metamorphic condition, approaching jasper. Its beds dip 45° to N. 70° W.; its cleavage 60° to N. 70° E. This rock is succeeded by Primal slates, under their more ordinary forms, and the Primal white sandstone, much altered, and with a peculiar fracture; here the cleavage dips 20° to S. 20° E., the strata apparently dipping at a high angle westward.

Approaching Willow Grove Tavern, we meet a more favourable display of the rocks. The white sandstone forming the face of a hill a few hundred yards S. of the road, exhibits, as it sometimes does in Montgomery County, thin laminæ, differing in tint, and separated by surfaces or films of well-crystallised mica. Here the dip is 70° to S. 80° E., the cleavage dipping in the opposite direction. From this point to Cashtown the strata display no outcrops deserving a record here. At Cashtown the rock is partially a conglomerate of a grey colour. Here we meet the margin of the unconformably overlying mesozoic red sandstone.

The mountain-gap of the Gettysburg and Chambersburg turnpike divides the altered slaty rocks on the S. from the unaltered sandstone on the N., until in our progress Eastward we reach the summit, E. of which the altered rocks cross the road, to range North-eastward along the Southern ridges of the mountain. The sandstone ridges which constitute the North-western spurs of the mountain, near Caledonia Furnace, jutting towards Green Village and Shippensburg, ranging North-eastward, become the main body of the mountain, the *altered* rocks lying on the Southern side. The same bed of altered rocks which lies between Caledonia Furnace and Cold Spring, and which crosses the turnpike South-east of the summit, is seen on the Southern side of the mountain, crossing one of the head-waters of Conewango Creek.

Crossing the mountain between Caledonia Furnace and Cold Spring, a distance of seven miles in a S.S.E. direction, no vestige of the white arenaceous sandstone is to be seen, until the foot of Green Ridge, at Cold Spring, is reached. The section displays rocks precisely similar to those on the East side of the mountain, on the railroad at Maria Furnace and at Holm's Creek, showing everywhere marks of alteration by igneous action. In the ridge W. of Caledonia Furnace occurs a talcose sandstone; and a fourth of a mile S. of the furnace, a highly-altered jaspery slate. Half a mile S. of the furnace, we meet a grey, spotted, silicious rock, evidently an altered sandstone; two miles S. of the furnace, a grey, altered, silicious rock, with dark blotches; and two miles N. of Cold Spring, a greenish slate, spotted with epidote, and charged with much white quartz. One mile N. of the same place, a reddish slate, speckled with white, occurs; and half a mile nearer Cold Spring is a red, jaspery, altered rock; all belonging, probably, to the thick system of slates composing the upper member of the Primal series, but greatly modified in texture by the intrusion of quartz, and by other igneous action. Throughout this section the strata dip invariably to the S.E. Though no anticlinal axis is visible, there is convincing evidence that the rocks have been upheaved along such an axis, and folded together, so as to make those on the N.W. dip in an *inverted* altitude to the S.E.—a feature very common throughout the whole range.

FIG. 25.—Section across the South Mountains along the Gettysburg R R.—1 *inch* = 3 *miles*.



A fifth section across the chain is furnished by the exposures of the strata along the Waynesburg and Emmetsburg Turnpike, and the cuttings of the old Gettysburg Railroad. Leaving the Auroral limestone of the valley, and entering the hills, the first actual exhibition of the strata met with is a South-dipping mass of Primal upper slates supporting Primal sandstone. These are probably inverted, forming the North-western leg of a wide complicated anticlinal flexure, the South-eastern limb of which would seem to be in the ridge containing the tunnels, several miles to the S.E., where the Primal sandstone and Primal upper slate dip at a moderately low angle South-eastward. Within this anticlinal belt there would seem to be three other anticlinal flexures, all lifting to the surface different portions of the Primal lower slates, and all showing a prevalence of moderately steep South-east dips, with rather steeper South-east-dipping cleavage. These lower Primal slates are highly indurated, and even decidedly crystalline, containing in some of their layers segregated specks, and even half-formed geodes of epidote, and other minerals. They bear strong general resemblance to the half-crystallised older Primal slates, just S. of Spring Mill.

Passing now to the Eastward of the Green Ridge Axis, we cross a high slope of slate, apparently the upper Primal in a synclinal fold, and then traverse a succession of outcrops of the Primal white sandstones and slates, to the Eastern base of the high land called Jack's Mountain, at the foot of which the older rocks disappear under the mesozoic red sandstone of the plain of Adams County.

The exposures in the sandstones near the Tunnel opposite Jack's Mountain, indicate a probable thickness of 1000 feet. Near the Tunnel at the North-west side of the mountain there is a hard epidotic rock, and not far from it highly-altered greenish slate, a rock found in several other localities further W., and containing layers of grey slate spotted with epidote. Further W. occurs epidote with asbestos.

Near Mincy Run search was made many years ago for copper ore, but nothing was found to justify the expectation of finding a productive vein of that mineral. A small quantity of copper ore was once obtained, and a furnace built for smelting it, in a small ridge N. of Jack's Mountain, but the exploration was abandoned. The metal occurs in the form of a green and blue carbonate, with a little native copper. Evidently the ore is not abundant.

DIVISION II.

AURORAL SERIES.

In the South-eastern district, the principal Auroral strata are those of the magnesian limestone. The Auroral calcareous sandstone (Calciferous Sandstone of New York) is in a few localities seen emerging from beneath it; but this formation would appear not to have been continuously deposited in this region. The other rocks of the series, the Auroral argillaceous limestone (Trenton Limestone of New York), generally so rich in fossils, as well as the overlying Matinal slates (the Hudson River group of New York), have evidently been removed at an early period, before the deposition of the Mesozoic red sandstone, by wasting waters that spared only the very lowest formations of the Palæozoic series. In some parts of the district the portion of the Auroral magnesian limestone which has escaped denudation is nevertheless of great thickness, not less probably than 2000 feet. It belongs, however, to the inferior part of the formation, everywhere comparatively destitute of organic remains, even in the more fossiliferous districts; and to this fact, arising from some general cause, and to the prevailing scarcity of fossils in all the formations throughout the region S.E. of the Kittatinny Valley, we must impute their non-appearance in the belts about to be described.

In the region before us there are three principal belts or tracts of the Auroral limestone; that of the Chester County Valley, that of Lancaster and York, and that of the South Mountains, between the Delaware and Schuylkill. A fourth, but much smaller outcrop, appears in the midst of the generally overlying tract of the Mesozoic or Middle Secondary red sandstone, in Bucks County, near New Hope. I shall describe, in the order in which they are here mentioned, these several areas of the formation, all of which I consider to have been originally connected by portions since washed away.

CHAPTER I.

GENERAL DESCRIPTION OF THE LIMESTONE VALLEY OF MONTGOMERY AND CHESTER.

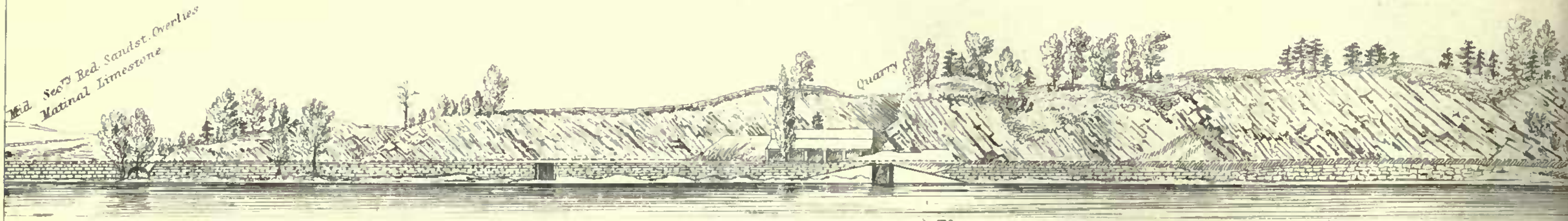
This interesting belt of the Auroral limestone, the borders of which have been already indicated in a previous Chapter devoted to the southern outcrops of the Primal sandstone, is worthy of a more full and connected description than it has yet received. Externally the tract, with its highly cultivated farms, numerous thriving villages, factories, furnaces, and mills full of prosperous industry, presents a scene unsurpassed in the United States. The soft, picturesque beauty of the plain or bed of the valley is much enhanced by the two ranges of slate hills, still clothed with the remnants of the natural forest. It lies between these like the deck of a slender shallow boat between its sloping sides. Its surface is in almost every part irrigated with running brooks of pure transparent water, and it is crossed by several swift-flowing, sparkling streams, as large as the rivers of some countries. The grandest of these is the Schuylkill. It is here a broad current, and bears deservedly the title of river. The enclosing hills, or two edges of the general upland, between which this valley lies, at an average depression of nearly 300 feet, are superbly carved into innumerable wooded ravines and narrow dells. This is especially true of the slope overlooking the valley on the South. From any point on the southern table-land near the head of one of its ravines, the view is truly enchanting: broad slopes of foliage and a shady dell fill the foreground of the picture; wheat-fields and pastures, orchards and snug tidy farm-houses, many of them of the dignity of country mansions, occupy for miles the middle distance; and the extended background is a rich succession of fading hills and far-stretching mountains. Breaking what might otherwise approach to monotony in the curves of the landscape, are here and there deeper gorges in the north and south barriers of the valley, furnishing waterway for the larger streams, the Schuylkill, the Wissahickon, the Brandywine in both its Branches, and the Octorara. The narrower parts of some of these are precipitous, and so shut in and wild as to present a most grateful contrast, in their tangled foliage, rough rocks, and mossy cliffs, with the neighbouring scenes of open pastures and sunny corn-fields.

NORTHERN AND SOUTHERN BOUNDARIES OF THE LIMESTONE.

This belt of limestone, which forms the Great Valley, and extends through the western half of Montgomery County, through Chester County, and Sadsbury and Bart townships, in Lancaster County, commences about a mile and a half S.W. of Willow Grove. Tracing it along its southern margin, we find it entering the northern corner of Cheltenham Township, crossing the Bethlehem Turnpike near the Running Pump Tavern, a mile below Flowertown, and thence passing to Spring Mill on the Schuylkill, where it crosses the river and follows Gulf Creek, through Upper Merion Township, into Chester County. After passing the county line, a little less than a mile S. of the Baptist Meeting-house, it follows the foot of the South Valley Hill about the same distance N. of Glassley and N. of the Paoli, to within a couple of furlongs of the Warren Tavern, and from thence half a mile S. of the Steamboat Tavern, and somewhat more to the N. of the Indian King. Near Downingtown the belt has decreased much in width, being little more than three-fourths of a mile broad. The belt passes about two furlongs S. of the town. From Downingtown, the foot of the hill indicates the margin of the limestone, which passes rather less than a quarter of a mile below Coatesville to Freeman's Mill, on Buck Run ; thence to Cloud's Mill, near Phillip's Tavern, on the Gap and Wilmington Turnpike ; and to the Octorara Creek, near the junction of Cloud's Run. In Lancaster County it follows Cooper's Run as far as the dam near the Valley Mills, but continues along the valley a furlong S. of the stream. We thence trace the same southern margin across the West Branch of the Octorara, about a fourth of a mile below Buckman's Tavern, and thence to Kunkle's and Eckman's Run, at which place the limestone terminates. On Eckman's Farm the line doubles back towards the E., and pursues nearly a straight course, by the Reform Meeting-house, to Buckman's Tavern ; thence running straight to the Octorara, a fourth of a mile above Noble's Factory. The greatest width of the limestone in Lancaster County is not much more than half a mile. Returning into Chester County, the northern boundary continues direct to Parkesburg. At Coatesville it passes one furlong and a half N. of the village. Two miles E. of Coatesville the belt widens, and the northern edge passes a fourth of a mile S. of East Caln Church. Still expanding, the northern margin passes one-third of a mile N. of Downingtown to West Whiteland Township line, where it is within a furlong and a half of the Valley Turnpike ; and thence continues N.E. for about three and a half miles. The width of the limestone, taken along the eastern township line of West Whiteland, is a little more than two miles ; and the northern margin is a nearly straight line from thence to the Valley Creek, which it crosses half a mile from its junction with the Schuylkill. As the belt passes into Upper Merion, it is overlaid on the N. by the red sandstone—a portion of which, jutting forward as far as the King of Prussia Tavern, conceals that part of the formation which lies to the N. of Reesville. From thence the northern line continues direct to within half a mile of Norristown, and, turning down towards Swede's Church, crosses the Schuylkill one mile below the bridge. Doubling S. a short distance from the river, it forms, in Plymouth Township, another loop, and then crosses the Ridge Turnpike at the fourteenth milestone from Philadelphia, and the Germantown Turnpike a little more than a quarter of a mile below the fifteenth milestone. It then passes into Whitemarsh Township, crossing the Wissahickon at Mather's Mill, a short distance below Sandy Run, following the run until it reaches the eastern extremity of the belt in Abington Township, near Willow Grove.

Chemical Composition.—In its chemical composition this limestone is, with the exception of an occasional stratum, highly *magnesian*, and many layers contain the carbonate of magnesia in the full proportion (namely, about 45 per cent) requisite to constitute the rock the peculiar definite chemical combination called *Dolomite*. More usually, however, the amount of carbonate of magnesia is somewhere between 10 and 30 per cent. As a general rule, the lower part of the formation is the most magnesian. This portion contains likewise a larger share of silicious and talcose matter than the beds higher in the series. The lime which this limestone yields, though invariably more or less magnesian, produces, on the whole, a very superior cement, the magnesia present in it giving the mortar the property of concreting with more rapidity than belongs to a

Pictorial Section, along Left Bank of Schuylkill, shewing Matinal Limestone from Red Sandstone below Norristown to Conshohocken Dam.



51° 50°

Yellowish White and Pale Blue Magnesian Limestone Micas L. Massive Pale Blue

White fine gr.d Mag.n Limestone Thick bedded Pale Blue and Whitish

50° 60°

Same thin bedded Slaty L. White and Pale Blue Magnesian Limestone Probable

80° 35° 45° 50°

Pale Blue Magnesian Limestone some beds Talcose and Slaty

Beginning of regular Inversion

70° 70° 70°

Mica Slate

Limestone all Inverted the same Continu

Engraved by W. & A.K. Johnston Edinburgh

cement of lime alone. Many of the more highly magnesian limestones can be made to furnish very excellent hydraulic cements.

Geological Structure.—The general geological structure of this populous and rich limestone belt, though curious, is extremely simple. Measured from one extremity to the other, the limestone, coincident very nearly with the bed of the valley, has a total length of about 58 miles. Its eastern end is just N. of Abington in Montgomery County, and its western at the source of Big Beaver Creek in Lancaster. In form, it resembles very much a long slender fish ; and this likeness is increased when we include as part of it the two spurs into which the bounding narrow sandstone ranges of Edge Hill and Mount Washington terminate, near the Pennypack, E. of Willow Grove. As pictured in the Map, it resembles a slender gar-fish, fins and all, with its tapering jaws asunder. The widest portion of the valley is between the Wissahickon and Valley Creek, where, from the southern barrier of the Primal slate to the northern margin of overlapping Red sandstone, the maximum distance is nearly three miles, and the average distance about two and a half miles. From the East Branch of the Brandywine it tapers very gradually and slenderly to its western termination. From the Wissahickon eastward it closes up much more rapidly, ending bluntly from the intrusion of the low anticlinal wave S. of Willow Grove, which spreads it into the broad snout already noticed.

Trough-like Dip of the Limestone.—The general structure of this first main belt of the Auroral limestone is that of a long and slender basin or synclinal trough, the southern side of which is much more steep than the northern. From the neighbourhood of the Gulf Mills, a little west of the Schuylkill, to its western end, this oblique symmetry prevails with scarcely any interruption. The strata of the southern side of the valley dip perpendicularly, often a little overturned into a steep south dip, but sometimes inclined steeply in the normal direction, or northward ; and it is only towards the western extremity, where the whole trough grows shallow, and rises as it flattens up and thins away, that the north dip ceases to be steep. The strata of the north side of the valley, or from the synclinal axis northward, dip at an average inclination of about 45° southward, or more strictly S. 20° E. But even this inclination is not absolutely constant, for in the wider central division of the valley this northern part of the trough contains in some places one or two short, low, and narrow anticlinal waves.

Between the Schuylkill and the eastern termination of the basin, the general simplicity of the synclinal structure is much more frequently interrupted by the presence of included anticlinal flexures, the more prominent of which—as, for example, those of the Conshohocken Ridge, or Bethel Hill, Barren Hill, and that of the Church Ridge, with others already described—lift to the day conspicuous local outcrops of the Primal upper slate and white sandstone. This eastern end of the basin is obviously much more undulated than its central and western portions, and the greater frequency of compressed waves in the strata is evidently connected with that longitudinal prolongation of the still sharper folds which corrugate the narrow zone of Gneiss embraced between the Attleborough sandstone range and the southern edge of the red shale. It is indeed but a local exemplification of a very general fact, that of the westward declension and cessation of the stronger crust-plications entering Pennsylvania from New Jersey. The position of this great synclinal trough between two sets of flexures, one set entering and enclosing it from the N.E., the other from the S.W., proves its relation to the same general cause which has preserved the troughs of coal, converting them to anthracite in a part of the Appalachian Chain just opposite. Indeed the whole tract of the Atlantic Slope and the Appalachians, embraced between the Delaware and Lehigh on the N.E., and the Susquehanna on the W., is a tract of general depression of the crust lying between the two more uplifted districts,—that of the mountains of New Jersey and New York on the one hand, and that of the Blue Ridge and the Juniata on the other. If, while inspecting the geological map of the State to assist our conceptions, we lift away in imagination the superficial deposit of Mesozoic red shale and sandstone concealing a part of the older rocks of the Atlantic Slope, we shall perceive this sinking and dying-out of the north-eastern and south-western groups of anticlinals much more obviously. It is to this fortunate abatement in amount of vertical uplift of the crust in the district between the Delaware and the Susquehanna, that Pennsylvania is indebted for the inestimable advantage above her sister States to the N.E. and S.W., of so remarkable an extension southward, or towards the tide, of her fertile and iron-yielding Auroral limestone; and it is to the same cause that she owes her inexhaustible basins of anthracite nearer to the seaboard markets by very many miles than any of the other Appalachian Coal-fields.

CONDITIONS OF METAMORPHISM OF THE LIMESTONE.

Throughout this limestone basin, the southern steeply upturned outcrop exhibits a far higher degree of metamorphism by heat than the northern, and this alteration appears greater where the strata approach most nearly the vertical position, and is greater still where they are inverted, that is to say, between the Wissahickon and the Brandywine. It is chiefly within these limits that the elsewhere bluish and yellowish limestone is in a condition of crystalline and granular marble, white, shaded, or mottled, from the dispersing and segregating action of a high temperature upon its changeable ingredients. An examination of the Map and Sections will show that all the marble quarries hitherto opened are included within this steeply upturned or overturned outcrop, the best of them lying within half a mile of the southern edge of the formation, or of some sharp inverted anticlinal like that of the Conshohocken Ridge. It is likewise along this most convulsed and cleavage-intersected side of the trough that, from the same cause, as will hereafter be explained, nearly all the largest, deepest, and richest deposits of brown iron-ore or hæmatite have hitherto been met with.

Throughout the northern half of the basin, especially where the limestone observes its usually very regular southward dip of seldom more than 45°, the rock is in the condition of a sub-crystalline, and even earthy or purely sedimentary magnesian limestone, and its bedding is for the most part very uniform and rather thick. Its colour is a pale greyish blue, except in neighbourhoods like that on the Schuylkill below Norristown, where a partial metamorphism has approached the northern border, and it is then, very frequently, a pale straw-yellow and bluish white. The interleaved thin layers of argillaceous matter which so frequently separate the beds of the limestone are in the condition of an indurated clay-slate, but seldom show even incipient crystallisation. In many instances wide bands of the limestone, along its northern outcrop, exhibit numerous cross-joints intersecting the beds in nearly all directions, and causing the rock in certain quarries to break into a mere rubble of small angular fragments, assisting much the labours of the quarryman and limeburner; but these joints, and the before-mentioned semi-crystalline texture, are the limits to which the metamorphism of the rock has reached, a true parallel slaty cleavage being seldom or never discernible.

But the state in which the very same beds exist, where they rise perpendicularly or with inversion to their southern outcrop after passing the synclinal turn in the centre of the basin, is very different from all this, and in striking contrast. The faintly crystalline and earthy limestone is here a distinctly crystallised, often a granular marble. Its colour is changed to a brilliant white, or to a mottling of purely white and dark blue, from the presence of segregated or half-developed graphite; and the dispersed ferruginous matter is here in a state of minute solitary crystals of sulphurate of iron disseminated through the body of the stone. The rock, instead of lying in thick, often massive beds, is cleft into thin plates by innumerable natural fissures or cleavage-planes, not parallel with the stratification, but dipping steeply southward or acutely across it, and these fissures are filled and lined with distinctly crystalline flaky talcose and micaceous matter, sometimes talc and mica fully developed. The partings of slate between the limestone layers have been converted to laminæ of talc-slate, in which there is often a cleavage-structure distinctly discernible, much more intimate than that in the altered limestone, but dipping in parallelism with it. Viewed edgewise, a fresh exposure of the most altered limestone, such as is visible on the River Schuylkill near Conshohocken, has the aspect of a blue and mottled marble, streaked with films of talc, and shivered by innumerable cleavage-joints; but viewed face-wise, the layers and fragments have the aspect of a talcose or micaceous slate, so copious is the covering of talc and mica upon their surfaces. (See Sketches of the Quarries.)

QUARRIES IN THE LIMESTONE, AND OTHER PRACTICAL DETAILS.

The portion of the formation which enters Abington Township is more slaty and fractured than that further to the W., and it also contains a larger amount of silicious or sandy matter. Those portions of the rock which are exposed, or are nearest to the surface, have in many places undergone partial decomposition, and have the appearance of a white calcareous sand. This sandy aspect of the limestone may be observed in all the quarries in the neighbourhood of Sandy Run, and also at many other localities. Unless the rock has undergone partial decomposition, the limestone is crystalline and granular. It varies in colour from blue to white, as a greater or less amount of carbonaceous matter chances to enter into its composition. Each of these colours is not confined to a particular stratum, but changes repeatedly in the same bed; and, indeed, the area occupied by one particular colour is usually very small.

The dip throughout the whole formation is remarkably uniform. Near Sandy Run it is towards the S. and S.S.E. Quarries and pits have been opened on almost every farm along Sandy Run. One of the largest in this vicinity is on the farm of Mr Fitzwater, near Fitzwatertown. The limestone is chiefly blue, the dip S.S.E., at an angle of about 60°.

On the turnpike opposite Sellerstown, a limestone quarry of some size is wrought, the rock making an excellent lime. An extensive quarry of the same nearly white variety of the limestone exists on Mather's farm. There the beds are crossed by very regular joints, giving the appearance of a stratification in another direction; the true dip is towards the S.

Near the Germantown Turnpike, about a fourth of a mile above the Plymouth Meeting-house, are good limestone quarries. Much of the stone in this neighbourhood is beautifully white, though some layers occur having a more or less bluish tint. The weathered surface of many beds is rough and sandy, showing some silicious matter in the rock.

Spring Mill.—North of the Furnace 200 yards there is a large quarry in the limestone near the southern edge of the formation, in which the dip is 85° to S. 10° E. The southern side of the quarry is massive and jointed, and the dip planes are almost effaced; the northern side is more thin-bedded and talcose, of a bluish-white colour, and its structure very crystalline.

In that portion of the Limestone Valley which occupies the southern part of Upper Merion Township, especially in the immediate vicinity of the Schuylkill, there are numerous and extensive quarries, furnishing a large supply of the rock, a portion of which is transported to Philadelphia, and other places, by the several railroads and the Schuylkill navigation; but a large amount is converted into lime on the spot, designed for the same markets.

A large quarry of the limestone is wrought on the west side of the Schuylkill, two or three miles below Valley Forge, where the rock is tolerably thick-bedded, and of a light colour. The quarried stone is conveyed to the river by a railroad, and thence taken by boats to the various limekilns. Extensive quarries have also been opened near the Valley Church, where the limestone is very similar to that of the last locality, dipping steeply south, being of a light tint, and furnishing an excellent lime. On the road from Glassley to Valley Forge, near the county line, there is a small bed of slaty talcose calcareous rock extending E. and W. about three furlongs in length towards Valley Creek. It constitutes a small hill, over the east end of which the road passes. Near Valley Forge occurs a stratum of felspathic rock like that seen at Barren Hill. It is exposed in the Creek, and occasionally appears overlying the Primal white sandstone at the foot of the North Valley Hill, a little East of the North Valley Church. The limestone near the White Horse Tavern in East Whiteland Township is occasionally talcose and slaty. Nearer the Steamboat Tavern the more usual granular structure prevails: throughout all this range, however, the rock yields an excellent lime.

At Downington the limestone is chiefly of a light colour, and compact. Several quarries of compact and granular limestone have been opened in this vicinity.

The width of the formation near the East Caln Church is reduced to about three-fourths of a mile. It is somewhat variable, being dependent, probably, upon the angle of the dip, which, however, is pretty constant. At Coatesville it does not exceed three furlongs. At Bell's Quarry, Midway, the rock is of a light colour. About one mile east of Trueman's Mill, we find a small bed of *white clay*, derived from the decomposition of an altered felspathic slate, lying between the limestone and the talc slates. In the vicinity of Buck's Run and Parkesburg the limestone becomes darker and more slaty. Passing Cloud's Mills into Lancaster County, it gradually declines in thickness, being at Cooper's Fulling Mill, in Strasburg Township, not more than two furlongs wide. At its termination in Bart Township it becomes more than usually sandy, especially near its margin. The main belt seems to terminate on Eckman's Run; but another small lenticular belt shows itself a mile and a half further to the west, on the premises of Mrs Bare, where the rock is quarried.

The practice of the landholders is to let out the right of working the quarry for a certain period, and the tenant during that time may excavate as much stone as he may require. Many quarries also are opened and worked by the proprietor for his individual supply. No record is therefore kept to enable us to ascertain the number of perches annually quarried.

TRAP-DYKES.

Near the Meeting-house, about a mile above Flowertown, a trap-dyke crosses the Bethlehem turnpike in a N.E. and S.W. direction. It appears to contain labradorite. It is about two and a half miles long, commencing near the north-west line of Springfield Township, and ranging past Bickell's Mill, on the Wissahickon, to the School-house half a mile further W. The protrusion of the dyke has not disturbed the adjoining strata to any serious extent. A marble quarry has been opened S. of the dyke, near Beck's Mill. The rock is granular, and its predominant colour is bluish. Crystals of *fluate of lime* occur in this quarry. About half a furlong N. of the dyke there is another quarry on Bickell's Farm, in which the beds are somewhat contorted.

Another dyke of trap crosses the Schuylkill near Conshohocken: commencing a little E. of the Perkiomen Turnpike, about half-way between Barren Hill and Marble Hall, it crosses the Norristown or Ridge Turnpike, ranges nearly along the crest of the Conshohocken Slate Ridge, goes through the village, and passing the river, in the bed of which it may be seen, it follows the summit of Bethel Hill into Delaware County, terminating near the road leading from the Lancaster Turnpike to the King of Prussia Village. This is by far the longest and widest trap-dyke of the valley or its borders, its length being a little more than six miles.

OF THE MARBLE OF THE LIMESTONE BASIN OF MONTGOMERY COUNTY.

The quarrying of marble in this district was commenced about 75 years ago, by Daniel Hitner. For the last 15 or 16 years the average quantity sent from the quarries of Marble Hall, owned and wrought by the present proprietor, Daniel O. Hitner, has been about 25,000 cubic feet.

The belt of marble is nearly three-fourths of a mile wide. Marble Hall, on the Perkiomen Turnpike, is the easternmost point at which good building-marble is wrought, though the belt is known to continue further. It extends thence to the Schuylkill nearly to the Chester County line.

The largest quarry of all is that of Marble Hall; here the strata dip to S. 20°, E. about 85°, presenting in one or two places a flatter inclination. This quarry is not less than some 400 feet in length, and at the top is 60 or 70 feet wide. The greatest depth to which the quarry has been sunk is 265 feet. At this depth were procured the blocks of beautiful white marble sent by direction of the State of Pennsylvania, and by the City of Philadelphia, to the great monument at Washington. At this depth the stratum of white marble, for which this quarry is chiefly wrought, has a thickness of 5 feet; but the usual thickness of this bed of pure white stone is 8 feet, that of the pure and clouded white together being generally about 20 feet.

Mr Hitner has quarried blocks 6 feet in thickness, though the general thickness of the blocks readily procurable does not exceed 2½ feet.

The only saccharoidal or statuary marble in this or any of the quarries, is found here at a depth of 120 feet, in a layer of only 6 inches in thickness. It is of a yellowish white colour and remarkable evenness of grain.

The white marble is used for monuments, and for the finer architectural purposes. It now sells for about one dollar per cubic foot.

To the south of the large quarry of Marble Hall, which, besides the white marble, yields much beautiful clouded or shaded stone, there is a quarry of blue and black marble, distant about 300 yards. This is owned by Mr Lentz, but now wrought by Daniel O. Hitner. This blue and black marble now sells for about 40 cents per cubic foot. It is used chiefly for fronts of buildings, for monument bases, &c. The thickness of the good blue marble in this quarry is 22 feet, and that of the black variety 8 feet.

Besides these quarries in the vicinity of Marble Hall, there are others about three-fourths of a mile north from Spring Mill; one set owned by Robert T. Potts, another adjoining his by Mr Peter Fritz. The marble of Potts' Quarry is chiefly of the clouded variety, besides a little white and some plain blue. The annual yield of this quarry is about 12,000 cubic feet.

The quarry owned by Fritz is at present but little wrought.

Next in position to the westward, but still seated in the same belt, are two quarries westward of the Schuylkill; these are Henderson's and Brook's, in Upper Merion Township.

Henderson's, the nearest to the Schuylkill, affords a plain blue marble, besides a little white. Both of these quarries are wrought at present to only a moderate extent.

A little south of the Valley Turnpike, about three and a half miles E. of Downingtown, is the extensive quarry of superior white marble which has for many years supplied Philadelphia with the beautiful article employed in so many of its public and private edifices. It is on the farm of Mr John R. Thomas. The beds on this quarry are slightly contorted. The portion worked for the marble separates into two bands. The rock occurs in massive beds, chiefly white, with sometimes a bluish tinge, and is quarried with great facility. It has been much used in the construction of the Girard College and other public buildings which adorn Philadelphia and the neighbouring towns. This marble is converted into a good lime, but its crystalline or granular structure causes it to crumble in the kiln, making it a little difficult to manage. The lime from this variety is much esteemed by masons, being sold in Philadelphia under the name of *Fish-egg Lime*.

The blue-mottled limestone or marble of Whitemarsh, occurring at the quarries not more than three-fourths of a mile north of the northern limit of the Primal Strata, is evidently on the south side of the trough, or folded synclinal axis of the district. This is further proved by its great steepness of dip, about 80°. It is, moreover, of the maximum degree of metamorphism or crystallisation; contains talcose or micaceous laminæ, and crystals of sulphuret of iron, &c.

Strontia.—Near Mr Hitner's House, Marble Hall, there occurs a thin bed of very ponderous rock, resembling closely a white crystalline marble. It contains, however, but a moderate proportion of carbonate of lime, and consists chiefly of the carbonate of strontia.

LOCALITIES AND STATISTICS OF THE IRON-ORE BANKS OF THE LIMESTONE BASIN OF MONTGOMERY AND CHESTER COUNTIES.

East of the Schuylkill.—The first ore ever dug in this valley E. of the Schuylkill was near Spring Mill, on the farm of J. Kirkner, at the excavation near the road leading to Barren Hill. This was about 30 years ago.

Hitner's Banks, near Marble Hall.—Iron ore seems to abound in great quantity in the deeper trenches or basins upon the limestone or marble north of the Conshohocken axis. From one locality near Marble Hall, Mr Hitner drew, in 1852, about 10,000 tons of good ore, and in 1853 rather more than 12,000 tons.

It is estimated by those best informed, that from the belt of country embracing the ore-pits at present wrought on this east side of the Schuylkill, the amount now taken is about 60,000 tons. This belt has a mean breadth of about one mile, extending from the Barren and Edge Hill range of Primal sandstone, northward to the middle of the valley beyond the narrower limit of the crystalline limestone or marble. Its length, as far as it has been hitherto explored by digging, is not less than seven miles. The ore is not equally plentiful all across this zone, but seems to range in long narrow strips, following, as it were, so many deeper troughs of ferruginous soil, covering the undulating outcrop of the limestone. The most productive belts seem to be one north of the Barren Hill range, and one north of the zone of white and clouded marble.

Good iron-ore occurs in scattered localities north of the general margin of the broad belt here mentioned. Thus Mr Wood, about one mile north of Marble Hill, finds a shallow deposit of iron ore in soil overlying limestone. This limestone would seem to be very thin here, for sandstone is reached at a small depth below it.

West of the Schuylkill.—There are several excavations for iron ore in the Narrow Limestone Valley south of Bethel Hill. Two of these localities are east of the gorge by which Gulf Creek passes through that hill.

One group of pits, or that which is nearest the Schuylkill, is somewhat more than one mile S.W. of it, and almost 150 yards S. of the road along the north side of the valley. One of the pits is mined by Mr Whitehall, and the other by Mr Fisher. The ore, which appears to be excellent, is smelted at Merion Furnace.

The old pit near the fork of the road, at the Baptist Meeting-house, has a shaft some 76 feet deep, and was soon to be reopened by the aid of a steam-engine. The ore is declared to be of superior quality. Formerly it partially supplied Merion Furnace. It is owned by Caldwell and Roberts. This ore rests on white marble. Another old opening of ore, now neglected, lies almost 200 feet further east on the S.W. side of the road.

About 100 yards N.E. of Henderson's Marble Quarry, in Upper Merion, is an ore-bank wrought by George Fisher. It is of considerable size, and until recently (1854) yielded good ore, but at present the brown hydrous oxide of iron has more earthy matter mingled with it than formerly.

George Fisher has a second ore-bank about 1250 feet N.E. of the one just named: here the ore is tolerably good. A new opening connected with this supplies ore to the iron-work, at Phœnixville. In these banks the average proportion of dirt to ore is about three to one.

Thomas Widdart's ore-bank, situated like those of Fisher on Henderson's property, is about 800 feet S. of Fisher's second opening. The quality of the ore here does not materially differ from that of the other banks. The old bank having nearly failed, a new one has been opened within the last two or three years.

Milliton's Bank, on Jones' Land, is situated W.S.W. of Fisher's, near the School-house ; the ore is pronounced good. It is smelted at Jones' Furnace, above Conshohocken. In this excavation the proportion of dirt to ore is about three to one.

Otto's Bank, on Potts' farm, contains good ore, but this has not yet been obtained in large quantities. Here the proportion of dirt to ore is about two to one. In 1854 this bank was but newly opened. Supplee and Hampton each have ore-banks in this vicinity, both of them of medium extent.

Hughes and Jones have several ore-banks in one group, leased for mining by sundry persons. No one of these excavations is large, though they form a considerable group.

The next neighbourhood in the valley at which iron ore is dug to any extent is in the vicinity of Howellville, Tredyffring Township. South of the village there is a small newly-opened ore-bank, from which good ore has been obtained.

Another ore-bank, owned by Mr Wilson, lies N.W. of Howellville, on the Swede's Ford Road, and this was but a small digging in 1854.

Woodman's ore-bank, on land of William Roberts, situated about 500 yards W. of the Valley Forge Road, and 500 yards N. of its forking with the Swede's Ford Road, yields an excellent ore. It contains the unusual proportion of two parts ore to one part dirt. The chief drawback is a rather copious influx of water. This ore is smelted at Phœnixville.

Nathaniel Jones and Charles Beaver have ore-mines near the Baptist Church, half a mile from Centreville. Buck and King have also opened a bank. All these three are in considerable excavations.

Samuel Beaver has an ore-bank near the foot of the North Valley Hill, about half a mile S.E. of the head of Valley Forge Dam. This bank is of considerable size, and yields good ore. It is unusual to find so large a deposit so near the northern margin of the valley, though unquestionably the lower, more magnesian beds of the Auroral limestone are much the most ferruginous, and where they support a deep deposit of earth, largely derived from their own disintegration, they constitute one of the main sources of the surface brown iron-ores.

Holland's Bank, about one and a half miles N.W. of Howellville, yields an excellent ore, which has been smelted at Phœnixville. The depth of the excavation, in 1854, was 43 feet.

Still further West in the valley, or past the meridian of the Paoli, there occurs another district of successful ore-diggings: the first of these is William Buchanan's Ore-Bank, about 400 yards N. of Oakland Hotel, on the railroad, and 100 yards W. of a cross-road. This is an excellent deposit, portions of the bank yielding two parts ore to one part dirt. The ore is taken to Jones's Furnace on the Schuylkill.

G. W. Jacob's Bank, situated between the North Valley and the Columbia Railroad, about two miles E. of Oakland, is a comparatively new excavation, but a promising one. The same proprietor has two other banks, about one-fourth of a mile S. of the Ship Tavern, both yielding well.

Maquire's Bank, on a cross-road, one mile N. of the Ship, is rather a large excavation of good ore.

Mr Evans has an ore-bank three-fourths of a mile E. of the Ship, which yields ore of a superior quality, and gave indications, in 1854, of a large deposit.

Frederick Neal's Ore-Banks, extending one-fourth of a mile upon a cross road, include three pits yielding good ore. He has a second opening on Lea's estate, near the North Valley Railroad. When seen it was a small newly-opened digging, yielding a good ore. A mile or more N.W. of Downingtown there is an ore-digging very near the foot of the North Valley Hill, but this has never been extensively opened, nor does it promise a large supply.

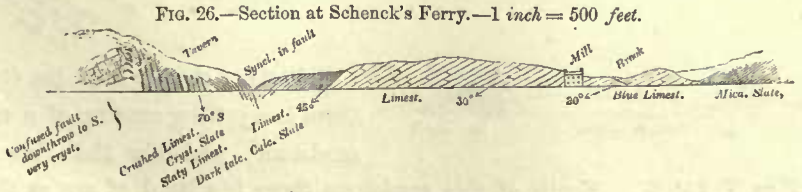
West of Coatesville there have been two or three excavations for ore towards the southern side of the valley between the West Branch of the Brandywine and Buck Run, but these have never furnished large supplies.

INSULATED LIMESTONE-BASINS IN THE PRIMAL ROCKS OF LANCASTER COUNTY, AND THEIR DEPOSITS OF IRON ORE.

There are several small insulated basins of limestone in the district of Primal rocks between the Main Synclinal Trough of the Chester and Lancaster Valley, and the Pecquea and Conestoga Valley. Four of these lie in parallel arrangement to the North of the West end of the main Chester and Lancaster Limestone Valley, all of them crossing the Big Beaver Creek. They are separated by anticlinal undulations of the Primal strata, and are bordered by the upper Primal slates. Their positions are shown on the Geological Map. The two longest, the southern and the northern, exceed one mile and a half in length, for so far do the topography and the soil indicate the limestone to extend. The two central ones are shorter.

Nearly West one mile from the most northern of these four basins, but apparently with an anticlinal ridge between them, lies a fifth small trough, crossing a tributary of the Pecquea; and North of this last is a sixth basin, the widest apparently of them all, intersected by the main stream of the Pecquea itself. It is on the margin of this little valley of limestone that Mylin's Ore-pit occurs.

FIG. 26.—Section at Schenck's Ferry.—1 *inch* = 500 *feet.*



Between the Pecquea and the Susquehanna there lie three longer narrow troughs of the limestone, insulated by anticlinals of the Primal strata. The most southern of these lies in the Valley of Eshalman's Run, terminating just at the river at Schenck's; this is about a mile and a half in length. It contains the Coleman Ore-Banks of the Safe Harbour Iron Works.

Due North of this, about a mile and a half, there is a longer basin of the limestone, which commences within a mile of the Pecquea, and runs westward for about three miles, crossing the Conestoga at Safe Harbour, and terminating in a little cove in the hills, about half a mile West of that point. This likewise contains iron ore; the margin of the limestone just West of the Conestoga, being the site of one of the deeper iron-ore pits of the Safe Harbour Company.

Still to the North of the last-described valley of limestone, and distant from it not half a mile, approaching it indeed very closely at the Conestoga, is yet another long narrow basin, stretching for almost four miles from near the Pecquea, crossing the Conestoga just above Safe Harbour Iron Works, and heading up half a mile to the westward in a little valley in Turkey Hill, precisely like the preceding. This last and longest of these troughs of Auroral magnesian limestone promises to afford much iron ore. West of the Conestoga there appears to be a considerable abundance of this valuable mineral, in its usual position among the strata which just connect the limestone with the Primal slates, and this is the site of a mine of some extent and depth. Near the eastern end of the same limestone valley occur other, apparently more extensive, strata of the same species of iron ore, occupying precisely the same geological position among the passage-beds between the two formations. The ore-pits are called the Rathfon Ore-Banks of the Safe Harbour Iron Works.

In this as in most of the other mines of iron ore connected with the Magnesian limestone, the position of the ore is precisely at the junction of the limestone and slate; it is indeed only a very ferruginous variety of the Metamorphosed Slate, regularly stratified and intercalated with it.

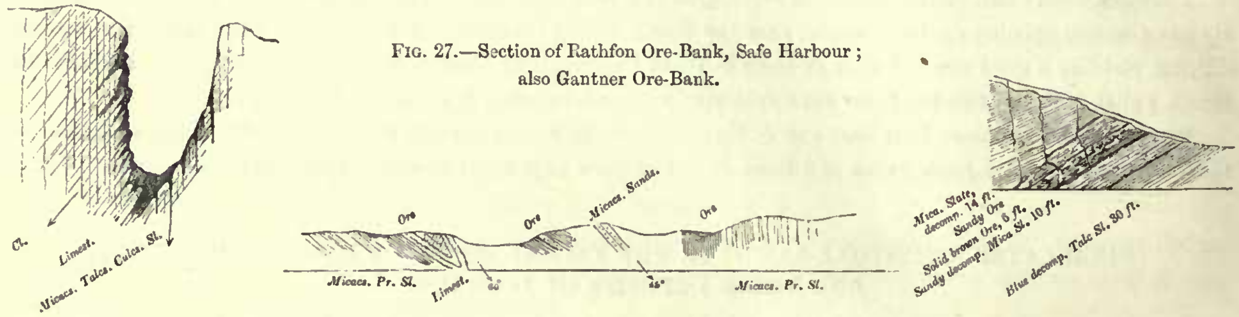
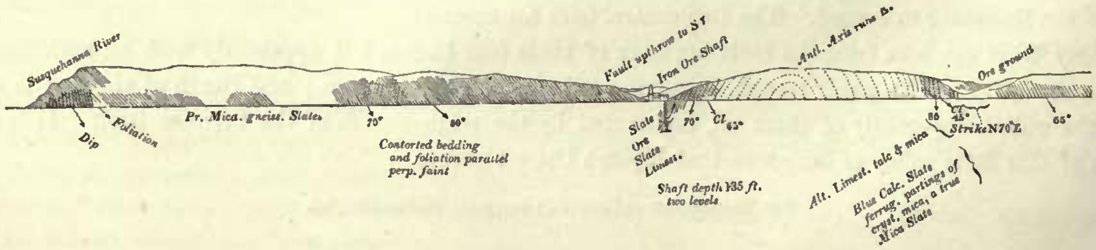
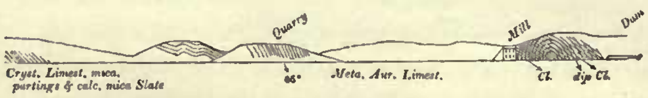


Fig. 27.—Section of Rathfon Ore-Bank, Safe Harbour; also Gantner Ore-Bank.

Wherever, as is most generally the case, the strata are intersected with cleavage-planes, and these are not coincident with the bedding, the more superficial portions of the ore follow for a certain distance the cleavage-dip, running out and off,—setting back successively into other more open fissures, but collectively descending nearly perpendicularly with the generally vertical dip of the strata, as in the Rathfon Bank..

Fig. 28.—Section of Ore-Ground east side of Conestoga Creek, Safe Harbour.





A little to the West of the Gantner Ore-Diggings there is a jutting outcrop of a micaceous crystalline sandstone, probably the Primal white sandstone altered. It dips 45° to N. 15° W. North of this sandstone there is a band of ore at the South foot of the River Hill, or in a straight line about one-half of a mile from the river. But the main range of the ore is just at the South foot of the tract of high ground occupied by the sandstone. The ore lies in decomposed sandy talco-micaceous slate between the sandstone, and an outcrop of limestone South of it. This important range of ore has been proved, and opened for a length of about half a mile. Its strike is N. 70°—75° E. The accompanying section exhibits the relations of the three ranges of ore of this vicinity to each other, and to the strata with which they are connected.

Mylin's Ore-Pit is an open excavation for ore at the junction of the limestone and black slates, in the little insulated limestone basin which crosses the Pecquea, at the mouth of the Big Beaver Creek. It is among the alternating beds which connect the two formations. This was a recently opened bank in 1854, and the product in ore that year did not exceed 3000 tons ; but the succeeding year it yielded about 100 tons per week. The ore itself is of only moderate richness. It is conveyed at present to Lancaster.

The Conewango Ore-Bank occurs likewise at the junction of the Auroral limestone and the Talco-Micaceous slates of the Primal series. Magnesian limestone outcrops within 100 yards South of the Mine Shaft, which has a depth at present (1854) of 54 feet. There is an open pit with an inclined plane for elevating the ore, the shaft and engine being used for pumping. The ore itself exhibits here a rather solid mass not very regularly bedded ; it is in fact the ferruginous slate disintegrated, and re-cemented by the action of the surface-waters, the whole mass consisting of more than one-third part of earthy matter. The ore itself has a richness of about 40 per cent metallic iron, and it is said to produce a metal of excellent quality. It is smelted at the Conewango Furnace, and also at York Furnace. The same year the product of the mine was 150 tons per week ; the bottom of the mass of ore had not been reached in the pits.

A small insulated patch of the limestone has escaped denudation on the Little Beaver Creek, near the Fulling Mill, about two miles from Strasburg. No ore has been found in its vicinity.

CHAPTER II.

AURORAL LIMESTONE OF LANCASTER AND YORK COUNTIES.

It is unnecessary to define in this place the very irregular boundary of this extensive tract of the Auroral limestone. Its Southern margin has been already traced in describing the Northern border of the Gneissic region, and its Northern limits will be given when we come to specify the outlines of the overlapping Red sandstone. Meanwhile an inspection of the Geological Map will convey a sufficiently exact idea of its shape and position.

Except in a few localities, the strata of this belt exhibit a less degree of metamorphism than belongs to the great altered tract last described. Though evidently much acted on by heat, their transformation has not amounted to a crystallisation, and a change of its blue hue to the white or mottled tint. In some places, however, the igneous action has accomplished this, and imparted to the more argillaceous seams the composition and aspect of a talcose slate.

It has been already mentioned, that this tract of limestone is traversed in an East and West direction, by a number of anticlinal axes. Many of these are closely-compressed folds of the strata, and such are not continuously traceable without great difficulty. The general Sections, from V. to VIII. inclusive, will sufficiently explain its structure with the aid of the Map. In consequence of the inversion of the beds, forming the Northern side of each anticlinal flexure, the whole district shows a prevailing Southern or South-eastern dip, but at the same time, much inequality in the degree to which the rock is broken in different localities. In a district like that of the valleys of Lancaster and York, where the limestone is very extensively employed for building, and for conversion into lime for the soil, it is of the utmost practical importance, in seeking for a suitable site for quarries, to give close attention to the situation of the places in relation to the anticlinal flexures. It will be found to be almost invariably the fact, that the strata lying to the S.E. of each anticlinal axis, and possessing a rather moderate inclination towards that quarter, are more free from irregular joints, and less crushed and shattered, than those upon the turn of the axis, or belonging to the inverted or northern side. Where sound rock is desired, the first position should be sought, and where broken stone is wanted, the latter.

In its chemical composition, there is no difference between the rock of this tract and that of the Chester County Valley. Investigations in the laboratory have shown it to contain quite as much magnesia in the corresponding parts of the formation. Many of the inferior layers, those, for example, which are exposed on the Lancaster and Harrisburg Railroad, upon the prolongation of the anticlinal of Chiques Ridge, are so magnesian as to be regarded as almost a true Dolomite.

The lower portions of the Auroral magnesian limestone are perhaps nowhere in this district better exposed than on the Susquehanna River below Columbia, near Strickler's Run, where they are seen passing, by a gentle gradation, with alternations, into the upper strata of the Primal series. An anticlinal in the ridge N. of Charlestown lifts the Primal sandstone to the level of the river, and from this point for half a mile N. to Strickler's Run, the Primal newer slate is exposed with a steep inverted and somewhat contorted dip, and an excessive amount of cleavage.

At Strickler's Run we meet with the lowest members of the Auroral limestones. Commencing with it, and proceeding northward, the strata are as follows, in the ascending order :—

1. Limestone, apparently very magnesian, sub-crystalline, of a light blue colour, with white spots and streaks. Dip nearly vertical and parallel ; thickness, 150 feet.

2. Blue talcoid slate, about 200 feet thick.

3. Limestone, mottled blue and white, and coarsely crystalline ; thickness, 15 feet.

4. Dark blue slate ; 20 feet.

5. Limestone, crystallised and brecciated ; the fragments flat, white, and coarsely crystalline, cemented by blue and less crystalline limestone. The occurrence of altered fragmentary limestone so low in the formation is not a little curious.

6. Bluish talcoid slate, 200 feet.

7. Limestone, crystalline magnesia, blue with whitish blotches. Dip nearly vertical, rather towards the South. It is intersected by irregular cleavage-planes, dipping generally 75° S. This outcrop is at the head of the sluice-way of the Columbia Dam.

On the Northern side of the synclinal trough contained between the anticlinal below Strickler's Run and that of Chiques Ridge, some of the same beds reappear.

The lower members of the limestone, those in alternation with the higher Primal slates just above Columbia, have been already treated of. These lower beds are seen in the corresponding part of the formation opposite the ends of Welsh Mountain and of Chiques Ridge. In relation to the cleavage, so conspicuous in the strata in this vicinity, a marked difference is observable between its dip on the two sides of the synclinal basin of Columbia, that of the steeply-dipping inverted rocks of the Southern anticlinal having, as we have seen, an inclination of 75° S., and that of the more gently-dipping beds of the Southern side of the Chiques anticlinal, a steepness of only 45° S. This is one instance among many proving that the original planes of deposition have exerted some degree of control over the subsequently-formed cleavage-fissures, tending to approximate them to parallelism with themselves.

The most Eastern appearance of the limestone in the large tract before us, is in the narrow valley of the Eastern Branch of Conestoga Creek, at a point three miles E. of Morgantown. Here the formation emerges from beneath the Mesozoic red sandstone, at the foot of the Welsh Mountain. The limestone along this valley has a general dip to the N.N.W. It varies in colour from blue to white and pink, and in some places is much mottled. These deviations from the ordinary blue tint, indicate more or less igneous actions, and a greater or less proportion of magnesia and other extraneous ingredients. Some of the striped and mottled layers would yield a marble of a pleasing aspect, susceptible of a moderately good polish ; but the difficulty is to discover among the north-dipping strata, an outcrop of beds sound enough to be quarried successfully, so generally is the rock, in this position, seriously shattered and jointed.

Trap Dykes, &c.—Near Morgantown, the strata are contorted. Layers of chert are here met with, embedded in the limestone. In this valley there are three dykes of trap-rock, all observing nearly a N.N.E. and S.S.W. direction. 1st, The first of these occurs a little E. of Churchtown. It has not perceptibly affected the texture of the limestone with which it is in contact. 2d, The second originates at the Conestoga Creek near Pennytown, and extends for more than one mile in a S.S.W. direction. 3d, The third crosses the Waynesburg and Lancaster Turnpike, about half a mile above the Sorrel Horse Tavern. Approaching New Holland, the limestone becomes silicious, and is much intersected by veins of igneous quartz, the fragments of which strew the surface.

About a mile N. of the end of the anticlinal of Welsh Mountain, there is a belt along which the strata are nearly horizontal, marking the centre of the basin N. of that ridge. The city of Lancaster is situated upon a tract of deep blue limestone, containing thin seams of talcose slate, all dipping 60° S. This belt is the prolongation of the south-dipping zone of the Southern side of the anticlinal of Chiques Ridge. The rock contains much sulphuret of iron in cubical crystals, the decomposition of which has imparted to the soil in many places a dark brown ferruginous hue, and has been the obvious source of the iron ore disseminated in numerous small deposits throughout the neighbourhood.

Near Millerstown, and also about three miles W. of Lancaster, there are several small dykes of trap-rock, which appear to have influenced, though very locally, the dip of the limestone in contact with them. Around Litiz the prevalent dip is towards the S. and S.S.E. Near Euphrata a quarry was opened a number of years ago, from which were obtained some good pieces of *marble* of a very light blue tint, and some of it decidedly shaded. A considerable quantity of *chert* occurs at this locality.

Auroral Limestone in the Valley of York.—Passing to the Western side of the Susquehanna, we observe that the belt of limestone is there much contracted in its width. Its Southern margin is near Creitz's Creek, below Wrightsville. Here it is quarried on the South side of the creek; another large quarry occurs on the North side of the same stream; while a third, in which we find some beds of variegated limestone, is wrought a little N. of the bridge. The Northernmost exposure of the rock near the river, is in a quarry a quarter of a mile above the bridge. The limestone here is nearly white, and has the aspect and texture of a marble, but is much traversed by cross joints, and is hence difficult to procure in large blocks. From this vicinity towards York, we notice several varieties of the limestone, some belts of which are highly magnesian.

The town of York is scarcely a mile from the Southern border of the limestone; and the excavation for the railroad, a little S. of the town, shows it to be slaty, denoting its passage into the slate on the S. North of the Codorus it is extensively quarried and converted into lime. One mile N.W. of the town are extensive quarries, in one of which occurs a beautiful flesh-coloured marble, but not in beds thick enough to be profitably wrought. On a hill half a mile W. of the town, a variegated, silicious, and calcareous rock is quarried for a building-stone.

That part of the limestone belt S. of the Pigeon Hills ranges between their Eastern end and the slate ridge to the S., and passing by Spring Forge, advances towards Hanover. S.W. of the forge, the belt becomes quite narrow and interrupted by bands of slate; but it may be traced continuously between the Slate Ridge, or "Barren Hills," on the S., and Pigeon Hills on the N.

Iron Ore.—A belt of *iron ore* is traceable along the Southern edge of this limestone, near the slate, for several miles. It passes a little S. of Hanover, and thence towards Littlestown. This ore was mined many years ago, but lay long neglected, owing to the inferior quality of the iron which it produced when smelted with charcoal, in consequence, chiefly, of its containing a considerable portion of the *oxide of manganese.* It occurs in quantity in a small hill two miles S.W. of Hanover, and at many other localities, and of late years has been successfully mined on a large scale.

The red sandstone passing from the West end of the Pigeon Hills, encroaches upon the limestone as it advances S., until, near Arnold's Mill, at the State line, it overlaps the whole of the formation.

Along the Southern base of the Pigeon Hills, in the slates N. of the margin of the narrow zone of limestone already traced, we find another belt of *iron ore*, of less length than that on the South side of the limestone. At Moul's, five miles N.E. from Hanover, the ore was dug about forty years ago. Much of it is scattered about the fields. Huge rocky concretions of ore protrude themselves at the base of a spur of the Pigeon Hills, about three-fourths of a mile to the N.E. The thickness of this deposit of ore is very great, not less perhaps than 100 feet; but the mineral is extremely silicious.

Limestone.—The Northern border of this division of the limestone, after ranging along the Southern side of the Pigeon Hills, folds round their South-western termination, and meets the overlying red sandstone on their Northern declivity. Extensive limestone quarries, producing a valuable lime, occur near the end of the hills. A limestone quarry exists on a farm near Conewango Chapel. Some of the beds yield a fine, compact, light-coloured variety, promising to be susceptible of a good polish as a marble. It affords a good lime.

The Northern division of the limestone is overlapped, as we have said, along the Northern base of the Pigeon Hills. It appears, however, a little E. of King's Tavern, ten miles from York. The course of the Southern margin of the overlapping red sandstone from this point is nearly N.E., passing within two and a half miles N.W. of York. Between York and the spot at which the limestone disappears at the base of the hills, it is much traversed by small ranges of slate.

The anticlinal ridge, consisting of the white Primal sandstone and slate prolonged from Chiques Ridge at the river, ranges along the Northern edge from Wrightsville nearly to York, within a mile and a half of which it terminates. The limestone folds round its Western end, and extends North-eastward between this ridge and another of silicious slate, running Westward from the Codorus. These uniting, the limestone ends in a point N. of the belt of silicious slate just mentioned, which belongs, apparently, to the upper portion of the Primal slate. We find another small wedge-shaped tract of the limestone crossing the river below Bainbridge, and extending Westward about a mile, when it is overlapped by the red sandstone, about a mile N. of New Holland. About half a mile W. of the river, near its Southern margin, we find lumps of *iron ore* in the soil.

Auroral Limestone at the Southern Base of the South Mountain in Adams County.—There is a narrow outcrop of the limestone near the foot of the South Mountain in Adams County, which, being of some economical importance to the agriculture of the neighbourhood, merits a brief description in this place.

The most North-easterly point at which we observe it is about a mile and a half north of Petersburg, where a beautiful white and compact variety is opened in a quarry. About half a mile S. of this, on the opposite side of a trap-ridge which intersects the formation, are other quarries. The rock is here of a light grey colour and remarkably soft, having been further removed from the influence of the once heated trap-rock. Another extensive quarry occurs in the same neighbourhood, two miles N.W. from Petersburg. Much search has been unavailingly made for limestone among the hills near the base of the mountain, ten or twelve miles Westward of Petersburg. The lime at present used is all brought from this latter place.

The next point at which we notice the limestone is about two miles N. of Fairfield. The rock here is of several shades of colour—purplish, greenish, and some of it nearly white ; it is also crystalline. On the West side of the Middle Creek, below Myers' Mill, it again shows itself, but is not quarried. The paucity of the exposures of limestone through this belt of country is due, unquestionably, to the extensive manner in which the older rocks are overspread by the Middle Secondary red shales and sandstones overlapping everything as far as the base of the hills.

SMALL INSULATED BELTS AND QUARRIES OF LIMESTONE SOUTH OF THE MIDDLE SECONDARY RED SANDSTONE.

In the district S. of the Middle Secondary red sandstone, there occur scattered, especially through Chester and Lancaster, a multitude of small patches—closely-folded basins I conceive them to be—of the Auroral limestone, bordered in some instances, though not in all, by the Primal white sandstone. S. of the Chester County Valley they lie almost invariably within tracts of the semi-metamorphic rocks, or crystalline Primal slates, but N. of that Auroral basin many of them are in the midst of what appears to be gneiss.

Proceeding in our description of these from E. to W. as usual, it will be convenient, for the purposes of classification, to note and trace those first which belong to the districts S. of the synclinal troughs of the Montgomery and Chester Valley and the Lancaster Valley, and then to review those that appertain to the Gneissic region of the Western part of Chester County.

It will be seen, I think, that by far the greater number of these insulated outcrops and small basins of limestone, though probably not the whole of them, are, with whatever rocks they are in contact, only outlying patches of the great Auroral limestone of Southern Pennsylvania, folded, metamorphosed, disguised, and mineralised by intense igneous action, or that transforming agency which invaded all the older formations of the district in which they occur. Many of the lesser and more insulated of these outcrops of limestone show themselves only in solitary quarries, but even in the great majority of such instances the topographical and geological structure of the adjoining ground strongly imply the existence of smaller or larger basins, or true synclinal troughs, resting sometimes on the gneiss, but in most cases embraced as folds within the talcose micaceous slates, which, upon the view I have adopted of the metamorphism of our rocks, are only the upper and lower Primal slates of the base of the Palæozoic system altered and crystallised. The limestone of these tracts exhibits all gradations of metamorphism, from the first change from earthy limestone to compact crystalline clouded marble, on to granular limestone and dolomite, and even to the most coarsely-crystallised calc-spar, with segregated crystalline graphite. In some cases the rock is almost pure carbonate of lime; in others, it is a true dolomite, or double carbonate of lime and magnesia. In some instances, again, it is free from any foreign minerals ; while in sundry other cases there abound numerous mineral species in all stages of segregation or development, from the most vaguely-formed crystalline nuclei to the most perfectly definite crystals. In certain examples we may distinctly trace the minerals through all these gradations of evolution, while in other instances we can ascribe their presence only to intrusive veins of true igneous or volcanic matter, bringing the foreign substances into the limestone, or commingling them with it.

The most Eastern locality of crystalline limestone in the district of the State we are now studying, is that of G. Vanartsdalen in Bucks County, about three miles W. of Attleborough. This should properly be enumerated among those in contact with the Gneissic rocks, for it is surrounded by hard crystalline hornblende gneiss. It stands aloof, at a distance of one mile, from the Edge Hill zone of Primal white sandstone which traverses Bucks County South of Attleborough. A hornblende gneiss is in contact with the limestone both N. and S., and even splinters and small blocks of the dark gneiss are involved in the crystalline limestone, as if ruptured from the walls of a fissure, through which the carbonate of lime of the quarry and the included minerals may have gushed up. Some of the thinner of these flakes of gneiss are excessively contorted and folded, indicating the whole mass to have been at one time in a pasty state, and so heated and squeezed as to have softened and folded the included gneiss. The limestone itself is a white crystalline mass, consisting of true granular limestone, granular dolomite, and calc-spar, full of specks of perfectly and imperfectly crystallised pure graphite, and replete with a variety of other interesting minerals. Some of these extraneous minerals exist as solitary crystals invested by the limestone, but the chief part occur in bunches and irregular veins through the general calcareous mass. It would seem as if some of these bunches and vein-like included masses had been elaborated from the materials of the gneiss caught in and melted up with more or less of the elements of the limestone. We are naturally led to this inference when we find that we can trace a regular gradation from the perceptibly stratified gneiss into these contorted strings and bunches of the crystalline minerals surrounded by or dispersed through the limestone. Some of these veins or strings of mineral matter present themselves in one part as true veins of felspar, modified at its edges by the presence of much crystallised mica and graphite. These felspar injections consist of tolerably pure labradorite. In some places the limestone includes large bunches of serpentine, associated with talc and other magnesian minerals. The presence of these naturally suggests a possible origin by segregation, either in full or in part, from the dolomitic layers of the originally magnesian limestone. The quarry also includes blotches and little nests of calc-spar and serpentine, and again of calc-spar and coccolite, sahlite, scapolite, and sphene. Mica occurs in several beautiful varieties, and graphite both in large regular hexagonal crystals and in curved irregular plates, and also in fibrous bunches.

It is worthy of remark that neither brucite nor spinel seems to occur here, though some of the conditions and associations are such as to suggest at first a hope of finding them.

The whole exposure of the limestone is between 200 and 300 feet long, and about 50 feet wide, and the quarry is opened on the South side of a small valley at the base of a low bordering hill. This valley may possibly be the remnant of a trough or basin of stratified magnesian limestone invaded by igneous injections along its Southern margin, and the fused and metamorphosed portions, as exposed in the quarry, may be almost the sole remnant of the mass reserved to us from a wasting denudation.

LIMESTONE QUARRIES OF CHESTER COUNTY SOUTH OF THE GREAT VALLEY.

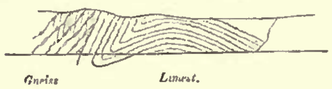
Belt First.—Giving our attention now to the limestone basins and quarries of Chester County S. of the Great Valley, we find that they nearly all lie to the W. of the Brandywine, and are so related as to constitute or to suggest the existence of at least 6 or 7 long and narrow limestone troughs or basins.

Brown's Quarry.—The most Southern of these within the State is a narrow trough ranging S.W. a length of more than two miles, from near the Delaware State line to near the forks of Whitely, or Whiteclay Creek. This narrow belt is bordered on both sides by gneiss, chiefly of the hornblende kind. Three principal quarries occur in the tract. The first encountered in going S.W. is Brown's Limestone Quarry, on a tributary of the East Branch of Whitely, near the Delaware line. It contains but little of the pure white limestone, the rock being much metamorphosed, and rather full of mica. It is, however, regularly stratified, and the lime furnished is well adapted for agriculture.

D. Nevins's Quarry.—This is situated to the S.W. of the preceding about three-fourths of a mile, being on the E. side of the East Branch of Whitely Creek. The strata dip at a gentle angle South-eastward, and a low anticlinal undulation or saddle lifts the talcose slates underlying the limestone to the level of the bed of the quarry, proving the total thickness of the limestone not to exceed 40 or 50 feet. This quarry likewise contains a small amount of white limestone, much brown mica occurring throughout the upper beds. It yields, however, a pretty good lime. The limestone is overlaid by the ordinary very micaceous rock, dipping on South side of quarry gently S., and there is a dyke of granite at the S. margin.

J. Nevins's Quarry.—This is the furthest opening South-westward within this belt, and seems to be near its termination. It is between the two branches of Whitely Creek, one mile above their junction. It has been wrought for 30 years by Mr J. Nevins, and includes both the blue and white varieties of the crystalline limestone. The white variety is a coarsely crystallised dolomite, producing an excellent lime for building. This occurs in massive beds in the lower part of the quarry, through a thickness of 20 feet. Above it there lies, in equally massive layers, a variety streaked with bluish and brownish bands, deriving its colours from the presence of an abundance of bronze-coloured mica. This coloured rock produces a grey lime. An anticlinal axis or saddle runs longitudinally through the quarry in a direction about N. 60° E. On the North side of this saddle the dip is about 45°, under a micaceous gneissic-looking rock. The dip on the South side of the quarry is to the S. about 30°. A contortion along the Southern edge of the quarry, and in the gneiss-like rocks which border it, presents an unequivocal indication of an inversion or fold by which the Gneissic rock is brought to lean over or rest upon the limestone which it elsewhere supports.

Fig. 29.—Nevins's Quarry.



Fragments of altered white sandstone occur in the vicinity of the quarry, to intimate that this is really a compressed trough of the Primal and first lowest beds of the Auroral strata. The whole breadth of the valley embracing the trough of calcareous rocks is not more than 200 yards.

There is a quarry of limestone in the State of Delaware, about three miles S. of the State line, distant about four miles from the above-described one of J. Nevins, in a direction not far from S. 30° E.

Belt Second (or that of Kennet Square.)—A line of detached limestone quarries extends from a point one mile S.W. of Chadd's Ford, on the Brandywine, to the East Branch of Whiteclay Creek, near Avondale Post Office. A branch of this trough, apparently a narrow or compressed fold in the strata, commences at Nickle's Quarry, includes Mendenhall's, which is likewise in Pennsburg Township, and embraces Goss's Quarries near Redclay Creek. It passes or unites with the Southern side of the main Kennet Square Basin in the vicinity of Pierce's Paper Mill. In the quarry of Mr Mendenhall the limestone is scarcely at all exposed, for, as Mr Mendenhall alleges, it lies very deep. It is overlaid by sandstone, which exhibits an apparent dip of 35° to the S. on the South side of the Quarry.

The main Kennet Square limestone-basin, divided from the foregoing narrow trough by a ridge of dark hornblende gneiss, extends from a point nearly N. of Goss's Quarry, to the East Branch of Whiteclay Creek, near the Avondale Post Office, as above mentioned. This trough is itself divided at its Eastern end by a wide low anticlinal hill of the Primal white sandstone, upon which the village of Kennet Square is seated, separating it into two branches or subordinate shallow basins. These coalesce into one wide basin a little W. of Kennet Square at the West Branch of Redclay Creek. Here the valley has a width of more than three-fourths of a mile, but the limestone does not apparently everywhere underlie it. This rock is quarried at Hoopes's, near the Creek. From this neighbourhood the belt steadily contracts to its Western termination beyond the East Branch of Whiteclay. The trough is bounded on the S. by hornblende gneiss towards its Eastern end, and by the lower Primal slates in the condition of micaceous and talcose slate towards its Western. On its Northern side the Primal white sandstone, underlaid by highly-crystalline Primal slate, everywhere borders the limestone at the foot of the Toughcanem Hill. The uncomformable relation of the Primal rocks and limestone to the gneiss is nowhere better shown than along the Southern side of this basin in the vicinity of Redclay Creek, and nowhere have we more convincing proof that the white sandstone and micaceous slates associated with it, bordering this trough, are of the true Primal series; for here they not only dip beneath the limestone all along its Northern margin, but rise in a regular anticlinal saddle through the limestone to divide the basin into two regular troughs. Throughout this belt the limestone, wherever it is exposed, has a highly crystalline structure, and the greater part of it is more or less magnesian or dolomitic. The Branch Basin south of Kennet Square exhibits a deep deposit of sand in the bed of the valley, extensively concealing the limestone. As already stated, the village of Kennet Square itself rests on Primal white sandstone.

Belt Third.—Next in order, proceeding Northward, is the longest and most continuous of all these limestone troughs. This commences on the E., near the Red Lion Inn, on the old street road, half a mile W. of the E. boundary of East Marlborough Township, and it ranges, curving gently Southward a distance of about nine miles, nearly to the Middle Branch of Whiteclay Creek; the trough is broadest between the West Branch of Redclay Creek and the East Branch of Whiteclay Creek, having there an average breadth of more than half a mile. The Western half of the whole basin is subdivided into three subordinate narrower valleys, all of them containing the limestone, more or less continuously, and all of them ending Westward in the vicinity of West Grove Friends' Meeting-house.

(1.) The first or most southern branch leaves the main basin about midway between the West Branch of the Redclay and East Branch of Whiteclay, and runs as a narrow, somewhat irregular trough for more than three miles, to a point a little E. of West Grove Friends' Meeting-house. There are several quarries of good crystalline limestone included in this lateral valley. One of these is near Hume's Grist Mill on Whiteclay Creek, and two others are at William Jackson's, towards the Western end of the trough. The point of junction of this small valley, sometimes called Pleasant Valley, with the main basin, is in the neighbourhood of Joshua Pusey's Mill. The furthest Westward point at which limestone has been detected in this narrow belt is a little S. of West Grove Meeting-house, where a tradition of the neighbourhood alleges it was met with many years ago in a well, and the topography seems to testify that the rock may prolong itself thus far. Excellent crystalline limestone, well adapted for agricultural and other uses, is quarried at William Jackson's; some of the beds being pure white carbonate of lime, while others consist more or less of dolomite. Brownish mica occurs in these beds, as in nearly all the limestone quarries of this class throughout the county. Adjacent to this quarry there occur scattered chunks of altered white Primal sandstone imbedding small crystals of Rutile.

In the mica-slate bordering the limestone of Pleasant Valley, there have occasionally been found segregated nodules containing a compact Kyanite.

Iron ore, but apparently not in large deposits, occurs S. of West Grove Meeting-house.

A tooth of *Mastodon giganteus*, apparently the fifth molar, was found some years ago in Pleasant Valley, about one mile E. of William Jackson's, on the East Branch of Whiteclay Creek.

(2.) The main trough of limestone throws off another and shorter branch, diverging, like the last described, from the Southern side, at a point between the two branches of the East Whiteclay Creek, not far W. of Hicks's Grist Mill. This smaller valley runs for about one mile and a half to a point a little N. of West Grove Meeting-house. The limestone has, as yet, been very little opened, or quarried, in this smallest branch of the general basin.

Though the limestone of this branch-basin, N. of Pleasant Valley, ranges apparently in a continuous belt, it has been quarried hitherto at only two points: the most Eastern one is where it was wrought some years ago by Robert Michener; and the more Western, at present wrought by Henry Story, is one-fourth of a mile N. of West Grove Meeting-house.

(3.) The main or Northern fork of the basin stretching towards the Middle Branch of Whiteclay Creek approaches to within half a mile of Kuisey's Clover Mill. Between the East Branch of Whiteclay and the Western end, it contains three or four considerable quarries of the crystalline limestone. The chief of these are known as Bailey's and Philips's. This last-named quarry, being situated farthest to the South-west of all the limestone deposits in this part of Chester County, supplies stone and lime for agricultural uses to a circle of country to the S. and W., extending to twelve or even twenty miles. Though it is evident from the topographical features of the whole limestone trough, from the Red Lion Inn on the E. to Philips's Quarry on the W., that it is a true synclinal basin, yet, from the appearance in its more central parts of occasional exposures of the upper Primal slates, and even of the subjacent gneiss rocks, it is probable that the bed of the valley is more or less undulating, and that the limestone is not everywhere absolutely continuous.

Uplifts of Gneiss, and Dykes of Granite.—In fact, there seems to extend an anticlinal axis of gneiss parallel with the Southern margin of the trough, the whole way from Joel Bailey's, a little West from the West Branch of Redclay, to Hicks's Grist Mill on the East Branch of Whiteclay, a distance of more than three miles. Connected with this line of uplift we may occasionally detect an obscure outburst of granite. The gneiss is itself massive and granitic. The anticlinal structure of this narrow protruded belt of older rock is well seen on the farm of Joel Bailey.

The following little sketch exhibits its features as exposed near his house. This anticlinal is said to range

FIG. 30.—Broken Saddle of Gneiss in Auroral Limestone on Bailey's Farm.

for nearly two miles to the Eastward, and to approach the East Branch of Redclay; but I have not traced it there.

Granite Dykes.—Just N. of Hicks's Grist Mill white granite shows itself in a low ridge, with contorted materials of the Primal white sandstone, borne through the limestone apparently by the intrusion of the granite.

There is a third dyke of granite, possibly a branch of that which ranges by Hicks's Grist Mill, which passes S. on the South side of Baker's Quarry, between the Branch Basin containing this quarry and that at William Jackson's. This dyke extends from near Baker's Quarry to a point about one-fourth of a mile N. of West Grove Meeting-house.

Another but shorter anticlinal uplift of granitic gneiss passes through the farm of William Jackson in Pleasant Valley, and appears to range for a mile or more North-eastward, passing under the knoll upon which the Locust Grove School-house stands.

This protrusion of the ancient gneiss rocks in anticlinal undulations through the overlying limestone, sometimes with traces of the Primal white sandstone and Primal micaceous crystalline slates, sometimes without any vestiges of them, is a feature confirming the evidence derived from various other phenomena, of the original unconformity in deposition of the Primal and Auroral strata upon the gneissic rocks.

Besides the quarries already enumerated, there are two or three good ones in the vicinity of Joel Bailey's. In all of these artificial exposures the general character of the limestone is very similar. It is generally a crystalline dolomitic limestone, sometimes very granular, disposed in massive beds, and contains, for the most part, more or less segregated mica, talc, and other minerals, the mica being rarely absent. In consequence of these extraneous substances, it seldom yields, when burnt, a perfectly white lime, though in nearly all the quarries some layers may be found so free from these foreign minerals as to produce, if care be observed in quarrying it, a stone convertible to lime of the very finest quality.

An interesting geological feature connected with this long and shallow trough of Auroral limestone, is the marginal outcrop of Primal white sandstone, and Primal crystalline slate, which almost everywhere borders it. These rocks are best seen along the old street road, and the lanes leading out from it, upon the Northern side of the basin. The conformable dip of the sandstone under the edge of the limestone, or towards the centre of the basin, is well exhibited at the street road opposite Joel Bailey's, and again at Taggart's cross-roads farther E.

In some of the quarries the limestone, especially near the Southern margins of the trough and its branches, is overlaid by micaceous and other crystalline slates, identical almost in composition with the micaceous crystalline schists of the Primal series. These are evidently but the intercalated argillaceous beds which almost everywhere belong to the lower part of the Auroral limestone formation. In truth, it would seem as if nearly all the limestone of this and the other small valleys of the district belonged to the very base of the formation, or that portion which presents a type of passage from the Primal or Schistose into the Auroral or Magnesian limestone series ; and this view is in consonance with the *obvious shallowness* of all the limestone masses embraced within these troughs.

Between the Southern border of this Street Road basin and the Northern edge of the Kennet Square limestone trough, or that bounded by the Toughcanem ridge, extremely little genuine gneiss shows itself at the surface, and that which does appear is the hornblende variety. It is obvious that the anticlinal belt which divides these two zones of Auroral limestone is here composed mainly of the older Primal slates, under the highly-crystalline micaceous type, which they wear so generally throughout all the Southern district of Pennsylvania. The true Gneissic or genuine Hypozoic metamorphic rocks, elevated only in narrow and broken fingers to the Westward of the Brandywine, here hardly lift themselves to the surface. The Primal white sandstone on both the N. and S. sides of the Street Road Limestone Basin, possesses all the features distinctive of this rock under its most metamorphosed form. Thus, where it dips gently Southward under the limestone on the North side of the valley near the Red Lion Inn, it contains the same minute broken crystals of schorl, the same thin partings of highly crystalline talc, and wears the same felspathic and semi-vitreous aspect which so strongly characterise it throughout all its outcrops bordering the great limestone valley of Montgomery and Chester counties.

It is not practicable to make out in strictly correct sections the undulations and dips of the strata, either in this or any other of the more complicated of these limestone troughs; but their structure is evidently identical with that of the Appalachian basins generally. The inclination of the rocks on the S. or S.E. side is either steep or inverted, unless where an actual dislocation forces the approximately level limestone to abut against uplifted walls of older gneiss or granite, while the dip on the N. or N.W. side is almost universally Southward at a gentle angle.

Both in Baker's Quarry in the Middle Branch of the Street Road Basin, and at Jackson's in the Southern Branch, the dip of the limestone is for the most part very gentle; that at Baker's flatly undulating, while that at Jackson's is at the low angle of 20° Southward into the base of the hill which bounds it. In William Jackson's Quarry well-developed crystals of phosphate of lime have occasionally been found; and the same mineral has been met with one mile WS.. of Chatham in a soil derived from the Primal mica-slate. Asbestos, in flexible sheets like paper, has also been found in Jackson's Quarry.

Neither in this nor in any other of these local isolated tracts of Auroral limestone and Primal white sandstone, do we meet with these rocks under a fossiliferous type. Obscure traces of the Scolithus, the sole fossil of the Primal white sandstone yet discovered in Pennsylvania, have been once or twice met with upon loose fragments of the rock; but this is the only instance of organic remains yet discovered. But this absence of fossils from these the most ancient of all the Palæozoic deposits of our country, need not at all surprise us, since their occurrence is extremely rare even in those basins of the same formations farther N., where the strata are much less altered and crystalline. Indeed, we know of no discovery of organic remains in the lowest beds of the Auroral limestone equivalent to the rock of these valleys in any part of the middle States.

Nearly in a line prolonged Eastward from the Street Road Basin, but some three and a half miles Eastward from its Eastern termination at the Red Lion Inn, there is an insulated outcrop of both the Auroral limestone and the Primal white sandstone just W. of the Brandywine a little below Brinton's Ford. This is at Goodwood's Quarry (formerly Harvey's). The quarry has not been wrought for several years. The limestone is for the most part sandy. Sandstone is scattered on the surface in the immediate vicinity of the limestone, but does not exhibit itself in place. Very probably this patch of limestone is an outstanding remnant of a more continuous belt which may once have connected it with that of the Street Road Basin, for it seems to lie in the same general synclinal wave in the older strata. In like manner, there can be very little doubt that the Eastern prong of the Kennet Square Basin, now embracing the detached quarries of Passmore, Mendon Hall, and Nichol's, was once prolonged across the Brandywine at Chadd's Ford; for we have the plainest proofs in the synclinal dipping of the hornblende gneiss of that vicinity, that a great natural trough or basin, competent to contain, until denuded, a belt of Primal and Auroral rocks, does here exist.

Belt Fourth.—N. of the long basin of the Street Road above described, and distant from it about two miles, there lies a much smaller trough or synclinal fold in the strata, containing a more or less continuous band of crystalline Auroral limestone, extending for about three miles from near the Drover's Inn, W. of Unionville, to nearly the N. line of London Grove Township. This narrow belt, marked by a narrow irregular valley, passes less than half a mile to the N.W. of West Marlborough Inn. In this vicinity, and likewise nearer to the Drover's Inn at Logan's Quarry, the limestone has been quarried to some extent. The most western quarry of this tract is J. C. Bailey's, situated about one mile S. of W. from the West Marlborough Inn; but the features of the country and the soil indicate that the limestone belt is prolonged considerably further South-westward in the direction of Cook's Grist Mill, though the rock has nowhere been opened.

Traces of the Primal white sandstone are to be met with on the margin of this small trough. Between West Marlborough Inn and London Grove Post-office, and even further to the S., the older Primal rocks, here in the condition of true micaceous slates, occupy a broad anticlinal belt, their south-dip towards the Street Road Limestone Basin being obvious in all the neighbourhood around London Grove Meeting-house and Post-office. Between the Friends' Little Meeting-house and Pusey's Grist Mill, we pass over the South-east-dipping outcrop of this Primal sandstone, the same which forms the Northern boundary of the Street Road Basin.

In Eli Logan's Quarries, about one mile W. of Unionville, the limestone dips to the S.E. about 30°, but irregularly, and with some remarkable folds. Resting apparently upon the limestone, there is a white gneissoid rock, possibly only a highly-altered or crystalline form of the upper Primal slates, in alternation with the limestone. It is a conceivable supposition, however, that this rock pertains to the true gneiss formation, and that all the strata in this quarry are inverted.

In the anticlinal belt which separates the Street Road trough of limestone from that of West Marlborough Inn, there would seem to be very little or no genuine gneiss W. of the Meridian of Unionville; but between the Brandywine Creek and Unionville, that rock does appear in occasional narrow uplifts. What seems to be genuine hornblende gneiss occurs near the Marlborough Meeting-house, some two miles E. of Unionville. The rock here contains some epidote.

BELT FIFTH.—The next and most Northern principal belt of the crystalline Auroral limestone occupies a long and narrow trough in the strata extending from Boardley Run, one mile W. of Marshallton, to near the South-west corner of West Marlborough Township, a distance of about nine miles. It is not certain that we have here a simple continuous synclinal trough; for though the natural exposures and the quarries of the limestone all lie in one very straight and narrow line, parallel with the other basins, and with the general strike of the strata of the country, yet these developments are too far asunder, and the topographical features of the belt are too irregular, to allow us to assert positively that the limestone is strictly connected along this whole tract. The probabilities are great, however, that it is.

Commencing with the most Eastern exposure, we meet the rock first in a quarry owned by Moses Bailey, on the East side of Boardley Run. The rock here yields a tolerably good lime for agricultural uses.

The next opening is in the quarry belonging to the Chester County Poor-house, about one mile further S.W. Here the rock is a highly-crystalline dolomitic limestone, containing in some, especially the upper layers, much segregated brown mica; in fact, certain of the upper beds include so much mica and quartz as to be entitled, from their composition, to be called calcareous gneiss. These upper beds are regularly interstratified with a micaceous gneiss-like rock; and even between the more massive beds of the true magnesian limestone, the parting layers are almost invariably either pure mica and talc, or a mixture of these with quartz, entitling them also to the name of Gneiss. The whole mass dips 35° to 45° to S., 20° E. Much as these overlying strata resemble genuine gneiss of the micaceous-slate variety, it is difficult, from the analogy of the limestone to that of other localities, unquestionably *superposed upon* the Primal crystalline rocks, to regard it as a merely intercalated mass between strata of the genuine old gneiss formation; it is more in accordance with all the results of our researches, to view this limestone and the associated gneiss-like beds as the passage-rocks between the Primal and the Auroral series, and to conceive that they hold their existing position, either from an inversion of the strata, or from a dislocation of the South side of the limestone valley of the Poor-house Farm, causing them to dip South-eastward against the uplifted older rocks which border them in that quarter.

In this quarry occur several interesting minerals, the most remarkable being the Chesterlite, once regarded as a variety of felspar; also Rutile and feathery Talc.

Next in order South-westward, among the quarries belonging to this belt of limestone, is that near Hoopes's Grist Mill, in an ox-bow bend of the Brandywine, in Newlin Township. Nearly two miles to the S.W. of this locality occur the quarries of Pierce and Edwards; these are about two miles to the N.W. of Unionville, on the road from Embreville to Doe Run Village. One mile and a half further to the S.W., and in the same exact line, is Connor's Quarry, on the road from Unionville to Doe Run. These three last-named quarries yield an excellent lime. The rock is very crystalline, and more or less dolomitic. In Connor's Quarry the strata dip at a moderate inclination to the S.E.; and to the N. of the quarry there is a band of South-east-dipping Primal white sandstone; and still further to the N. are the older Primal slates in the condition of quartzose mica-slate, likewise dipping to the S.E., or beneath the Primal sandstone, at an angle of 45°. Micaceous sandstone, and occasionally Primal white sandstone, border the synclinal valley on its N.W., throughout its whole length; but the white sandstone is to be detected only occasionally. The older Primal slates, highly crystalline in their structure, likewise bound the valley on the S.E.; but in some of the exposures of the limestone we are at a loss to determine whether the rocks of this character, leaning upon the dolomite, are the true Primal slates inverted upon the limestone, or overlying schistose beds belonging to the alternating portion or base of the Auroral limestone series. It is pretty evident that these rocks, as they occur on the South side of the limestone at Connor's Quarry, are really the Primal slates inverted against the limestone.

The furthest opening in the limestone in this synclinal is that of Baker's Quarry, half a mile E. of the W. line of West Marlborough Township.

It is more than probable, from the remoteness of the localities at which the limestone has been discovered, and from the irregular features in the topography of this belt, interrupting the continuity of the valley, that limestone does not occur in one unbroken trough, but has been lifted and washed out of the shallow basin in several sections of its length; and it is indeed natural to suppose that the synclinal structure itself is not perfectly regular; the more probable view being, that the whole tract is a chain of short and narrow basins, rather than one long, continuous, straight trough.

About two miles N.W. of West Chester, in the valley of Taylor's Run, and therefore E. of the Brandywine, there is a small outcrop of limestone on land belonging to Caleb Cope. This is so nearly in the line of the long chain of quarries of the Poor-house synclinal, that we are almost induced to conjecture that it may belong to the same trough with them, and that it is an outstanding remnant of the Auroral rocks preserved from denudation.

BELT SIXTH.—The last and shortest of all the synclinal tracts of the crystalline magnesian limestone S. of the Great Valley of Chester County, is that in the vicinity of Doe Run Village. This extends for rather more than a mile in a S.W. direction, parallel to the Valley of Doe Run, from near the village to the vicinity of Passmore's Mill. Near the first-named locality, the limestone is exposed in a quarry owned by a Mr Hayes, and it is again developed S. of the Doe Run stream, near the South-western end of the belt, in quarries owned by Hoopes and Jones.

No true gneiss shows itself N. of the Poor-house Chain of Quarries, but all the strata embraced between that long synclinal line and the great limestone valley of Chester County, pertain to the Primal series. This series is here evidently of great thickness; it is made up of micaceous and talcose slates, embracing a large proportion of fissile clay-slate of the nature of roofing-slate, and it apparently belongs to the same place in the formation which embraces the Susquehanna zone of roofing-slate, making so conspicuous a feature near the State line.

The comparatively rare occurrence of white Primal sandstone outcropping from beneath these lower beds of the Auroral magnesian limestone, which have just been described, should not surprise us when we reflect that that rock is extremely thin, and is sometimes altogether wanting along the Southern margin of the deeper and more continuous limestone-trough of the main Chester County Valley; and when we also remember that this formation, nowhere very constant in its thickness over wide districts of county in the middle States, exhibits in Chester County a progressive general increase of its mass as we advance to the Northward. This fact alone makes it very probable that the non-appearance of the sandstone round some of these Southern basins results from their lying outside of its continuous area, and it may serve furthermore to explain the absence of its characteristic fossil the Scolithus, even where the rock itself occurs.

INSULATED LOCALITIES OF CRYSTALLINE LIMESTONE WITHIN THE GNEISSIC DISTRICT NORTH OF THE CHESTER COUNTY VALLEY.

1. Turning now to the localities North of the Chester County Limestone Valley, and noting them in the usual order from E. to W., the first which we meet with is a small outcrop about three-fourths of a mile W. of the village of Charlestown, and a little N. of Pickering Creek. It is near Clevenstine's Foundry. The bed or mass appears to be but a few feet in thickness, and resembles more the layer in gneissoid micaceous rocks, or even an intrusive vein of impure calcareous spar, than a folded bed of limestone at the passage of the Primal and Auroral series. It was at one time quarried to a small extent, and burned in a limekiln, but the lime was dark and impure.

2. The next outcrop of limestone occurs near the village of Kimberton. This is a small bed of altered crystalline limestone, chiefly in the condition of calcareous spar, with scattered crystals of plumbago, epidote, and two or three other minerals. It occurs very near the contact of the Gneissic rocks and overlapping red sandstone, and adjoins a dyke of syenite, to which it owes, most probably, its highly crystalline structure.

3. Another locality is near the Northern road leading from Kimberton to the Yellow Springs; it adjoins the large ore-pit on Mrs Lewis's farm. This limestone has been quarried, and converted into good lime. Ascending

French Creek, the next is at Schuyer's Quarry, near Bachardt's Oil Mill. This outcrop extends Westward into the next farm.

4. There is another on the South side of French Creek at Vanlear's, half-way between Pughtown and Coventry, but S. of French Creek. This also has been quarried and converted into good lime.

5. A little to the W. of Vanlear's is a small exposure of the limestone at Christman's, which has been converted into an excellent lime.

6. There is another small exposure S. of Coventry Village.

7. Following the South Branch of French Creek occurs another isolated bed in Nautreul Township, S. of Miller's Grist Mill.

8. A little W. of Warwick Furnace we meet with another small bed in contact with micaceous Gneiss.

9. A dyke or vein of sparry limestone forms the Northern wall of the iron ore-pits at Crossley, one mile N. of Knauertown. It is in contact with a wide dyke of granite, and includes several crystalline minerals, and exhibits every indication of having been at one time in a state of fusion.

10. There is a long and narrow strip of limestone in Uwchlan Township, W. of the Little Eagle Tavern; its total length, as indicated by a succession of sink-holes, and one or two small quarries, and by two or three wells sunk into it, is probably one and a half miles. The rock is a very coarse, crystallised, white sparry limestone, abounding in numerous little flakes of plumbago. It has been found to produce, when properly burned, an excellent white lime. It lies chiefly in low meadow ground, and under a deep covering of soil, and being very narrow, is obscurely seen. It is therefore very difficult to pronounce whether it is an igneous vein or a bed in the metamorphic gneissoid strata, or again a closely-folded narrow trough, doubled between, but yet overlying these.

CHAPTER III.

AURORAL LIMESTONE OF THE SOUTH MOUNTAINS BETWEEN THE DELAWARE AND SCHUYLKILL.

It remains to describe the several narrow belts of the Matinal limestone of the Eastern division of the chain of the South Mountains. Commencing on the N., we have the limestone of the Lehigh, a part of the great Kittatinny Valley. Passing down the Delaware, from the mouth of the Lehigh, this belt of the limestone, measured obliquely in the direction of the river, has a breadth of about two miles, showing first a Southern dip of about 45°, which diminishes, then passes into horizontal, and then into a gentle Northern dip, forming a synclinal basin. Between the Northern dip last mentioned, and the uplifted gneiss to the S., there are indications of a narrow anticlinal elevation of the limestone, connected probably with a high narrow ridge of the gneiss which appears in New Jersey. Passing round the end of the first ridge on the Pennsylvania side, consisting chiefly of gneiss and syenitic rocks, we come to a narrow belt of limestone which extends Westward from the river, about two miles, occupying a little recess between two spurs of the chain. This limestone is quarried near the river, at Ihrie's, and at Harman's. A large amount of lime is made at the latter place, which is four miles below Easton, and some of the stone goes down the canal to various points in Bucks County, where large quantities of it are used. Much jaspery chert, with chalcedony and quartz, derived from the limestone, strew the fields about a mile from the river.

The prevailing dip of the gneiss in the Lehigh Hill is to the S.S.E. at a steep inclination. Between these strata and the Northern belt of limestone, we find indications, near the Delaware, of the presence of the Primal white sandstone. This formation, if really present as a continuous stratum, must be of inconsiderable thickness. Resting, as it does, directly on the violently uplifted Gneissic rocks, its unfrequent appearance at the base of the hills may, however, be explained in part by the crushing it has undergone, and by the mass of transported fragments concealing it from the sight.

The Southernmost of the two spurs of the Lehigh Hill, mentioned above as bounding the little narrow tract of limestone, forms the Northern limit of another larger limestone valley, the Southern boundary of which is Frey's Run. The limestone of this valley, dividing the Northern belt of primary rocks from the middle one, terminates on Frey's Run, about two miles W. of the Delaware, the last exposure of the rock being at Stout's Quarry, where its dip is Northward. The breadth of this tract, measured along the river, is very nearly two miles ; here at Uhlersville, about five miles below Easton, it is extensively quarried and converted into lime. The strata, which have been tilted into a nearly vertical position, differ much in the quality of the rock in the different layers.

Bounding this limestone valley on the S., we have the broad belt of crystalline rocks, which I have designated as the middle ridge of the whole mountain-chain. The rocks of this range, comprising chiefly massive strata of gneiss and beds of syenite, cross the Delaware into New Jersey, forming a ripple called Rocky Falls. South of this middle belt, and N. of the Southern or Durham Ridge, which is a prolongation of the Musconetcong Mountain of New Jersey, there lies another narrow but rather longer tract of the limestone, occupying the valley of Durham Creek. The breadth of this tract of limestone, measured along the river from a point opposite the mouth of Musconetcong Creek to the mouth of Durham Creek, is about one mile; the upper edge of the limestone, N. of the village of Riegelsville, being much obscured by a covering of diluvium, and the lower bordered by the Creek, along which it is well exposed, from its mouth to the neighbourhood of Springtown. A little W. of the old Philadelphia Road, and N. of that to Springtown, the limestone appears on the South side of the creek, dipping 60° nearly S. The dip is also Southward in several places east of Springtown. The existence of a steep Southern dip along the South side of this valley is in strict analogy with the position of the rocks generally in the valleys of the whole South mountain-chain, and implies an overtilting of the strata to the N. This *folding* of the beds upon themselves in the synclinal axes of our first great mountain-chain, though remarkable, is a prevailing feature from Vermont to Tennessee.

East of Springtown there is a low ledge of Primal sandstone lying N. of the road, and following the course of the creek in a North-eastern direction.

South of the Durham Ridge of Gneiss, there occurs another smaller strip of the limestone, bounded on the S. by the conglomerate and red sandstone of the Middle Secondary formation. This small tract shows itself a little W. of the river, near Monroe, occupying the South side of a little stream. It is well seen in a quarry, inclining 75° to a point a little E. of S., and in another, where it dips to the S.E. at an angle of 30°. Its last appearance towards the W. is at the old Philadelphia Road, where the red sandstone overlaps it.

The next detached tract of limestone which claims description is that of the Little Saucon, along the valley of which it may be traced, though with rather obscure exposures. The rock shows itself in the creek about half a mile N. of Lower Saucon Church, near a blacksmith's shop. Further up the creek, it is said to have been dug, but found too slaty for use. Its last occurrence along the stream is near the intersection of the road and the creek, where it is well exposed, and of a good quality. At this place its strata dip 40° North-westwardly. Ascending the creek beyond this, the Gneissic rocks show themselves, and the country becomes wild and rocky.

The next tract of limestone is that of the main Saucon Creek, in the valley of which it is the prevailing rock, from within a mile of the Lehigh, almost to the very source of the stream. This belt, ranging in a N.E. and S.W. direction, separates the group of ridges terminating on the Delaware from the rest of the chain, stretching towards the Schuylkill. Conforming to the general curvature of the valley of the Saucon, the limestone occupies, throughout the greater part of its course, both sides of the creek, and ascends, for a little distance, some of its tributaries. The lowest point at which it shows itself is about a mile and a half N. of Hellertown, and by the channel of the creek, nearly two miles above its mouth. Expanding soon in breadth to embrace both channels of the Saucon, which here divide to form an island, one part of the tract sweeps Eastward, running up between two spurs of the gneiss, until it terminates in a point about two miles E. of Hellertown. Half a mile E. of the town, the limestone is seen dipping to the N.W. A little to the E. of this, between two small hills of gneiss, a short belt of the Primal sandstone appears, the rock resting directly on the gneiss, and dipping towards the W.N.W.

Beginning with the termination of the limestone, E. of Hellertown, the Southern edge of the formation will be found running thence, in a general South-western course, along the Southern side of the valley of the Saucon. About the Lehigh County line, a spur of the gneiss, running down between the main creek and a small Southern tributary, insulates the limestone in the valley of the latter, in the form of a little cove, where it is opened in two quarries, belonging to Abel and Flexer. The general margin of the formation follows the Northern foot of this spur as far W. as the South Branch of Saucon, where it doubles round it ; the limestone here running Eastward to form another little cove between the spur already mentioned and a second small belt of primary to the S. of it. The North-western point of the spur includes a small tract of the Primal sandstone. The edge of the limestone now crosses over to the Western side of the South Branch of Saucon, extends in that direction about half a mile, and then curves back by the S. and E. until it again meets the stream, where the limestone disappears beneath the overlapping Middle Secondary rocks. Within the curved edge just traced, is included, therefore, a third small cove of the limestone, lying, like the others, between two jutting points of the gneiss. Coming back now to the general Southern margin of the limestone, we trace it from the South Branch of Saucon, first Westward and then South-westward, along the main creek nearly to its source, about a mile and a half N.E. of Shimer's. From this point, the whole way down the Northern side of the valley of the Saucon, the other, or North-western margin of the limestone nowhere departs far from the border of the stream, following the curvatures in its course, with considerable regularity, to the point where we commenced our description, about a mile S. of the Lehigh. The limestone of the main belt of the Saucon is quarried E. of Hellertown, as already mentioned ; also at a point about half a mile S. of it, dipping at both of these places towards the N.W. It is opened also at Upper Saucon Church in a quarry on both sides of the road, where the dip is towards the S. South of the creek, about half a mile from the intersection of the Allentown Road with that leading S. from Upper Saucon Church, occurs Toger's Quarry, where the rock dips to the S., as it does at a point N. of this, near the creek. Crossing the creek on the road to Allentown, we find another quarry, the strata dipping to the S.S.E. ; and another about two miles higher up the stream, a little W. of the road which leads Eastward from Emaus. Here the dip is gentle and a little N. of E. Still further up the creek, beyond the Upper Saucon Township line, there is a large quarry, owned by several persons. The prevailing dip just here is to the N.E. The last exposure of the limestone is about a mile and a half above this in a quarry. The dip is gentle, and to the S.W.

Upon the South Branch of Saucon, the limestone is opened at a quarry, and at Berger's Mill. Wherever the limestone on this tributary rests in contact with the overlapping red shale and sandstone, it loses its usual clear blue, and acquires a light, bluish pink colour. In this vicinity the rock is highly magnesian. The rock is crushed, consisting of innumerable small square fragments.

Besides the continuous belts of limestone now traced, there occur, in the region of these hills, several small isolated patches, remnants, as it were, of a once widely-diffused tract of the formation, the main body of which has been broken up and swept away. Commencing with the Easternmost, we meet with one of these at the Bucks County line, at a point about a mile and a half W. of Springtown ; and about a mile further Westward another, where the rock has a dip of 35° to the S.E. and is quarried. These two patches lie embraced in the gneiss. In Upper Saucon Township, S. of the creek, and a little W. of the Allentown Road, we meet with a third, near the top of a ridge of gneiss, where the rock is exposed at Erdman's Quarry. The limestone is of the common blue variety, but it abounds in fissures filled with white carbonate of lime. Its proximity to the agricultural district S. of it, where no limestone occurs, and its elevated position, which facilitates hauling, cause it to be somewhat resorted to.

The only other detached localities of the limestone in Lehigh County occur in Upper Milford Township. One of these is about one mile S.W. of the uppermost exposure of the limestone on the Saucon. It is near the source of one of the main branches of Perkiomen Creek. Another lies in the Western corner of the township, half a mile S.W. of Hampton Furnace, being also on a tributary of the Perkiomen ; and a third is on the Hasacock Creek. The rock here is in close proximity to the Middle Secondary red shale and sandstone.

There remains one other tract of the limestone to be spoken of as occurring S. of the Lehigh. It occupies a recess in the Gneissic belt immediately S. of Bethlehem. Commencing on the Southern bank of the river, about a mile above the town, the line which divides it from the gneiss runs in a crescent until it meets the river again some distance below the town. Thus enclosed, it forms properly but a part of the great belt of the Kittatinny Valley.

The greater part of the limestone of the several tracts above described belongs to the blue varieties of this rock so familiarly known. It is by no means, however, invariable in its composition, very many bands being more or less magnesian, and some so highly so as to furnish, when properly treated, an excellent hydraulic cement. Occasionally we meet with a somewhat rare and interesting variety, possessing an *oolitic structure.* Bands of this description are met with above South Easton, and also on the Bushkill, and again N. of Chestnut Hill. These oolite beds of the Auroral magnesian limestone are not unfrequent in other parts of the State ; their common position seems to be near the bottom of the formation.

DURHAM CAVE.

Before quitting our description of the limestone, we may devote a few words to a cavern which occurs in this rock on Durham Creek. Its position is a little N. of the stream, and not far from the Delaware. It has a length of about three hundred feet, an average height of twelve, and a breadth varying from four to forty feet. The floor of the cave is not level, but descends as we penetrate to the interior. Its rough walls are adorned with few pendants or stalactites. Much of the bottom of this cave is covered with water, the level of which is influenced, it is said, by that of the Delaware. About half-way down occurs a narrow lateral cavern, terminating in the form of the letter T. The general direction of the main gallery is S.W., becoming S. towards the remoter end. The rocks show an anticlinal axis about twenty yards S.E. of the entrance of the cave, the direction of the axis and the cave nearly coinciding. This cave was found many years ago to contain some interesting fossil bones, an account of which will be found in another Chapter.

ZINC MINE OF THE SAUCON.

Immediately N. of Friedensville is the zinc mine of the Pennsylvania and Lehigh Company. It is a superficial excavation or open quarry, the entrance being by a slope way. The principal ore is calamine, or a silicious oxide of zinc : it appears to be abundant, and has been somewhat extensively mined. It appears to occur irregularly injected into the limestone, which dips perpendicularly on the North side of the mine, and as steeply as 85° on the South side. The limestone is much injected with thin veins of quartz. It would seem that the vein of ore coincides very nearly with a closely-compressed, perpendicular, synclinal fold in the limestone, possibly with a synclinal fault.

This mine was commenced about 1853, and wrought for three years. The ore is smelted at Bethlehem, and converted into white paint. The vein would seem to range South-westward, or along the synclinal axis or possible fault.

BOOK II.

THE KITTATINNY VALLEY, OR THE SECOND PALÆOZOIC DISTRICT.

CHAPTER I.

BOUNDARIES AND FEATURES OF THE VALLEY, AND CHARACTER OF THE STRATA.

PERHAPS no subdivision of the State exhibits better-defined natural boundaries than the Kittatinny Valley. It is limited on the S. by the chain of the South Mountains, which is not, however, a continuous barrier, but consists of one range of hills from the Delaware to the Schuylkill, and another from Dillstown in York to Maryland, with an intermediate space, presenting a more broken boundary. Its Northern limit is the Kittatinny Mountain, separating it by a very regular natural wall from the mountain districts on the N.W.

Dimensions.—The entire length of this belt from the Delaware to Maryland is about 165 miles. Its mean breadth in Northampton, Lehigh, Berks, and Franklin, is 15 miles ; and in Lebanon, Dauphin, and Cumberland, between 10 and 11 miles. Throughout its whole extent it presents a gently-undulating surface, approximating to a level plain, with here and there a belt of low hills.

The inequalities of its surface are greatest along the Northern side, near the foot of the Kittatinny Mountain. Some detached hills of slate appear in the middle of the valley near the Schuylkill. A high degree of fertility characterises the soil of all the Southern half of the district.

Embracing only the Auroral and Matinal rocks in their South-eastern type, the geological composition of this belt is necessarily simple, nor do the several formations undergo any very marked changes in their longitudinal range. The structural features of the valley, though peculiar, and well deserving of attention, are almost as uniform. The strata are everywhere bent into oblique and closely-folded flexures, with South-eastern dips. But few organic remains are to be recognised, the more highly fossiliferous formations, the Matinal limestone, Trenton limestone, and Matinal black slate (Utica slate), hardly appearing in more than one or two neighbourhoods.

Cleavage.—In nearly every part of the district the strata display an excessive amount of *cleavage*, the divisional planes or joints dipping almost invariably towards the S.S.E., or parallel with the planes which bisect the anticlinal and synclinal flexures.

The direction of the cleavage is therefore approximately constant, whatever may be the local dip of the rocks. This cleavage has originated *subsequently* to their elevation and contortion, but seems to be intimately related in its direction with the position of the anticlinal and synclinal axis planes. These latter were obviously the planes of maximum temperature in the crust, while the strata were as yet newly upraised, being the portions most crushed and fissured, and the channels of escape for the intensely-heated elastic vapours which we must suppose accompanied the energetic lifting and folding of the rocks. Conceiving the cleavage to be a species of crystallisation effected through molecular polarities excited in a definite direction, it is not difficult to comprehend how these forces might be awakened throughout the entire rocky mass of a given district by the action of innumerable alternately-disposed planes of maximum and minimum temperature, and to imagine such a region to represent, as it were, a stupendous *thermo-electric series*, capable of engendering the corpuscular forces or polarities, and of producing parallel alternating planes of maximum and minimum cohesion resulting in cleavage.

A glance at the general sections which cross the Kittatinny Valley, will convey a correct notion of its structure, and show the singularly constant South-eastern dip of all the strata, with the oblique direction of their compressed flexures.

Character or Type of the Formations.—The Auroral calcareous sandstone occurs as a thin formation in the vicinity of the Delaware, presenting very nearly the type which it exhibits under the name of Calciferous sandstone in New York. It seems not to have been everywhere deposited, for we meet with only occasional indications of it further towards the S.W. along the valley.

The Auroral Magnesian Limestone.—The formation which underlies the entire Southern half of the valley, though a stratum of enormous thickness, is not susceptible of accurate measurement in any part of the district, from the frequency and obscurity of the flexures that traverse it. Except in Cumberland and Franklin, and a few localities E. of the Susquehanna, it does not embrace the higher fossiliferous beds of the formation. It consists for the most part of two varieties of limestone, one highly magnesian, the other less so ; and these form an extensive alternation. The magnesian variety constitutes by far the largest portion of the mass, especially in the lower and middle divisions. Many of the inferior strata are very crystalline, and present, when weathered, a harsh granular surface. These frequently contain the full proportion of the carbonate of magnesia essential to the constitution of the rock called Dolomite. Some of the lower beds are very sandy and ferruginous. To the disintegration of these I impute in part, at least, the very ferruginous quality of the sandy loam which fills the depression in the surface in so many places in the Southern side of the valley, and in some localities includes such valuable deposits of hæmatitic iron-ore—brown hydrated peroxide of iron.

In Lehigh, Northampton, and elsewhere, there occur in this belt, low in the formation, layers of a decidedly Oolitic limestone. These are well exposed near Allentown. A similar rock occupies the same place in the series in Centre and Huntingdon counties, and is extensively met with in Virginia, and also in East Tennessee, in the prolongation of the Kittatinny Valley. So wide a geographical range manifests a remarkable extension of that peculiar condition in the waters which gave rise to the oolitic structure. Alternating with the lower limestone masses of the formation, are beds of sandy talcoid slate without fossils ; these link the Auroral with the underlying Primal series. They are especially conspicuous on the Susquehanna at Columbia, in the more Southern belt already described. In the middle and upper parts of the formation, which have their outcrop chiefly in the Northern half of the limestone belt, there is a large proportion of a purer limestone, which may be recognised by its dull blue colour, and the freedom of its weathered surfaces from any incrustation. This is the variety best adapted for the making of lime, and for use in the smelting of iron.

The Matinal Limestone (the equivalent of the Trenton Limestone of the Geological Survey of New York) is distinctly recognisable near the Delaware, also on Martin's Creek, and at a few other localities within the belt of the Kittatinny Valley, but chiefly E. of the Lehigh.

It is a more North-western rock, however, so far as respects its fullest development in Pennsylvania, appearing in the anticlinal valleys of Mifflin and Centre counties, and other central portions of the Appalachian Chain.

South-west of the Susquehanna we occasionally meet with a few organic remains in the uppermost portion of the limestone, as near Carlisle, and again near Chambersburg, but these are referable apparently to the higher fossiliferous members of the Auroral magnesian limestone, known to contain several species in common with the Matinal limestone.

Matinal Black Slate and Matinal Limestone on Martin's Creek.—On Martin's Creek the passage from the limestone to the Slate formations exposes at least 300 feet thickness of the Matinal Black Slate (Utica Black Slate) without fossils, and from 300 to 400 feet thickness of fossiliferous Matinal limestone (Trenton), all dipping at 30° on an average to N. 30° W., and all thoroughly cut up by cleavage-planes, which for the most part are almost absolutely horizontal, except where they curve in a sort of waving or sigmoid bending between the planes of bedding.

In the Matinal limestone are to be found *Chætetes lycoperdon,* and two or three other characteristic well-known fossils of the formation.

Beneath this argillaceous limestone (Trenton) may be seen, in the first anticlinal S. of the boundary of the limestone and slate, the smooth massive marble beds visible on the Mohawk, and characteristic of the higher member of the Auroral series.

The Matinal Black Slate (the equivalent of the Utica Slate of New York) is also seldom or never present in the region of the Kittatinny Valley; at least, it has not been recognised by its distinctive organic remains. I regard the thin bed of brownish carbonaceous slate met with at the junction of the Auroral limestone with the Matinal slate in the neighbourhood of Nazareth and on the Bushkill, as probably representing the margin of the formation.

A black slate, identical to all appearance with that which overlies the Auroral argillaceous limestone (Trenton) on Martin's Creek, and which is undoubtedly the equivalent of the Matinal Black slate (or Utica), occurs in all the hills ranging N. of the margin of the limestone through a belt some two or three miles broad. We meet it on the road between Easton and the Water-Gap as far as 10 miles from Easton. At the hill 7½ miles from Easton, it displays beautiful oblique rhombic prisms, produced by the intersections of the planes of bedding, the cleavage and the cross joints. Here the dip of the cleavage has an unusual direction, which, instead of being towards the E., or even E. 20° N., is generally in this belt towards the Highlands, or the igneous range of New Jersey; that is to say, about S. 30° E.

The Matinal Newer Slate (corresponding to the Hudson River Slate of New York) exhibits throughout the North-eastern portion of the valley very nearly the type which it wears on the Hudson, embracing, in addition to a large preponderance of grey argillaceous slate, many beds of arenaceous slate, and some masses approximating in the coarseness of their fragments to true conglomerates. Further to the S.W. the formation acquires a somewhat more exclusively argillaceous character, not, however, to the exclusion of all the coarser layers, many of which are visible on the Susquehanna at Harrisburg. Along the North-western side of Lebanon and Dauphin, the lower and middle members include numerous beds of red and yellow slate, which impart to the soil an aspect not usual in other parts of this belt. These coloured layers, especially distinct in the region N. of the Swatara, are more seldom met with either E. of the Schuylkill or W. of the Susquehanna. They represent a very common type of the formation as it occurs in the central parts of Virginia in the range of the same great valley. At the Delaware River, and in several localities between it and the Lehigh, the more purely argillaceous portions of this rock have the composition and cleavage-structure of roofing-slate. One outcrop of this roofing-slate lies near the base of the Kittatinny Mountain.

Organic remains are rarely visible in this Matinal newer slate of the Kittatinny Valley, partly from their actual sparseness in the rock, and partly from the effects of the cleavage-fissures which almost everywhere traverse it, and impart to all its fragments surfaces not coincident with the planes of original deposition, upon which alone the fossils are arranged, or could be more readily detected.

Geological Structure.—Little need be said in detail of the structure of the Kittatinny Valley, as an examination of the general sections cannot fail to render perfectly intelligible the character of its numerous flexures, and the cause of the almost universal prevalence of a South-eastern dip. It is extremely difficult to recognise, and especially to trace along the surface, the individual lines of anticlinal flexure within the slate-belt of the Northern side of the valley, in consequence of the imperfect exhibition of the true dip, disguised as this is by the more prominent feature of the cleavage-planes all dipping in one direction. Within the outcrop of the limestone the recognition of the axes is more easy, on account of the less thorough obliteration of the dip by the cleavage-fissures, and the greater conspicuousness and individuality of particular layers in the strata. Some of the more conspicuous anticlinal and synclinal flexures in the limestone are readily discernible on the Delaware River, where the rocks are less closely folded than further Westward ; but on the Schuylkill and Susquehanna a very close inspection of the edges of the strata is frequently requisite before we can detect the place of the abrupt change in the direction of the dip. In most cases the space occupied by the actual curve or flexure is very narrow, often not more than a few yards, while the dip on both sides is approximately parallel, or towards the same South-eastern point, and at nearly the same angle. It may be stated as generally true, that the inclination of the less disturbed, or South-eastern leg of the arch, is from 45° to 60° ; while that of the North-western inverted side is from 60° to 80°. There is seldom, indeed, a difference of more than 20° in the dip of the two sets of strata, and in some cases they have been compressed into almost perfect parallelism. In the quarries, which are becoming numerous upon the Eastern bank of the Susquehanna below Harrisburg, an opportunity is afforded in two or three instances of detecting the anticlinal curve and abrupt inversion of the strata on the Northern side of it. Other more numerous examples are visible in the cuttings of the railroad between the Susquehanna and Chambersburg, more particularly in the Western part of Cumberland County and in Franklin County.

CHAPTER II.

AURORAL LIMESTONE OF THE KITTATINNY VALLEY, FROM THE DELAWARE TO THE SCHUYLKILL.

THE North-eastern division of the Kittatinny Valley, or that included between the Delaware and Schuylkill Rivers, is separated somewhat unequally by the line of boundary between the Auroral limestone and Matinal slate. Commencing at the Delaware a little above the mouth of the Pequest, it recedes very gradually from the river until it reaches Martin's Creek, near its mouth, leaving but a narrow belt of limestone on the Pennsylvania side. From Martin's Creek the Northern limit of the limestone pursues the base of the Slate Hills, crossing the Bushkill near the intersection of the road from Easton to the Wind-Gap. Thence sweeping a little more to the Westward than in its former course, it ranges to Nazareth and Bath, passing through the centre of these villages. From Bath its course is to Siegfried's Bridge on the Lehigh, the line previously passing S. of Kreidersville.

Crossing the Lehigh, the junction of the limestone and slate inflects more to the Southward, passing Gordon's Creek near Sieger's, and leaving Toglesville about half a mile to the S. It intersects the Berks County line near Haus's, and thence taking a less Southerly course, passes half a mile N. of Kutztown and S. of Moslem Church, approaching Maiden Creek about half a mile N. of the Friends' Meeting-house. Here it curves Southward, and ranges parallel with the valley of Maiden Creek, which it leaves, and crosses the Schuylkill at Althouse's Bridge, nearly two miles above Maiden Creek, and about nine miles from Reading.

The line of junction of the two groups just traced is rendered somewhat irregular in certain neighbourhoods by the intrusion of narrow belts or tongues of slate into the limestone, and of limestone into the slate, the results of anticlinal and synclinal flexures. We meet with such N. of Trexlerstown. Besides this interlocking of the formations, a few local tracts of the slate appear within the general limits of the limestone, involved in the synclinal folds of the latter, and on the other hand, small anticlinal belts of the limestone occur inside of the area of the slate. Such are the natural results of the folding and subsequent denudation to which the strata have been subjected.

At the Delaware River.—Beginning the more detailed description of the Auroral limestone at the Delaware River, I shall allude, in the first place, to the comparatively narrow belt embraced between the general boundary of the South Mountains and the narrow spur of gneiss called Chestnut Hill, N. of Easton. This trough of the limestone, which terminates in a synclinal point a few miles E. of the Delaware in New Jersey, between two ridges of the Gneissic rocks, seems to possess the true basin-like structure, without the usual inversion along its Southern side. The strata resting against the foot of Chestnut Hill show where they are exposed on the Delaware, a Southern dip of about 45° diminishing to a very gentle one at the mouth of the Lehigh, and becoming a true Northern dip near the base of the Lehigh Hills. The lower beds are silicious, and many of them highly magnesian, and included in them are many layers and nodular bands of dark-grey chert, portions of which are reddish. Fragments of this chert are abundant in the soil N. and N.W. of the town of Easton.

The limestone, especially the middle part of the formation, is quarried in a number of places; for example, on the N. side of the Bushkill, about one mile and a half from Easton, where it is extensively excavated, and converted into lime. There are other large quarries below the mouth of the Lehigh, along the Delaware Canal, which supply much limestone to Bucks County, where the farmers use anthracite coal for burning it into lime for fertilising the soil. The iron ores along this Southern belt of the limestone near the Lehigh have been already alluded to in the Chapter upon the Rocks of the South Mountains.

North of Chestnut Hill.—Much of the surface of the wider belt of the limestone embraced at the Delaware between Chestnut Hill and the foot of the Slate Hills, is covered superficially, in the vicinity of the river, by drift and river alluvium; but when we proceed Westward to within two miles of Martin's Creek, the limestone appears abundantly exposed. Near the river-side, about two miles above the mouth of Martin's Creek, hæmatitic iron-ore, apparently of good quality, was at one time dug, but the mine is no longer wrought. From the general shallowness of the earth over the limestone, there would appear to be but little probability of the existence of a large deposit of ore in this locality.

At the mouth of Martin's Creek the belt of limestone is very narrow. The rock, which is here nearly horizontal, is quarried ou the river-bank. A little below the stream the dip is North-Westward, and somewhat further down there is a small anticlinal flexure. Advancing S. we meet with S.E. dips five miles above Easton, at Sandt's, and some distance lower down with a N.W. dip, about 45°, proving another more considerable normal axis. The limestone of this neighbourhood is more silicious than that nearer the slate, and the lime derived from it is less esteemed. It belongs evidently to a lower position iu the formation. Still descending the river, we cross another anticlinal axis, and lastly a synclinal trough, on the Northern side of which the South-eastern dip is 45°; while on the Southern, at the base of the steep anticlinal of Chestnut Hill, it is nearly perpendicular.

It is a fortunate circumstance that the purity of the limestone adjacent to the Northern edge of the belt adapts it so well for agricultural use, since the soil of the slate country to the North is particularly benefited by the application of lime, aud there is a rapidly growing desire among the farmers for this valuable fertilising agent. Several quarries are now wrought along this border, especially S.W. of Bath, and the limestone is conveyed into the slate tract, and there burned into lime.

SECTION FROM EASTON NORTH ALONG THE DELAWARE, INCLUDING THE MINERAL AXIS OF CHESTNUT HILL.

Examining more closely the rocks along the Delaware northward from Easton, the Auroral limestone is seen well exposed in the hill N. of Easton, nearly to the axis of Wolf's Hill. Probably there are two anticlinals in the limestone in this space.

On the South side of Wolf's Hill (Chestnut Hill) we come upon the massive altered rocks, Primal slates, and sandstones.

This ridge consists, in the axis or centre of the arch, of a coarse, highly crystalline porphyritic granite, and both the North and South flanks contain a great variety of remarkably altered rocks.

Both on the South and North sides of the axis the Primal sandstone is very well exposed. On the South side it seems to constitute a separate low arch. It is here largely displayed on the river-side, and is very vitreous, much fused, and generally of a reddish hue; but a white sandstone of the more normal character is associated with this.

The slates and limestone which overlie this are entirely metamorphosed. The former is a crystalline dolomite, including much serpentine and various beautiful magnesian minerals. The slates have been rendered magnesiau and talcose, and in some instances highly micaceous.

In contact with a vein or dyke of coarse granite near the South side of the gap, the slaty rocks, with bedding and dip still clearly perceptible, are seen changed into chloritic, and micaceous, and hornblendic slates, looking much like members of the Gneissic or older metamorphic series; and yet among the coarser grits, thus altered, we may discern the quartz pebbles unchanged. Towards the North end of the gap, after passing a great thickness of very massive, coarse, felspathic granite, such as already described, we come upon a massive-bedded rock, having all the appearance of regular stratification, and dipping steeply North. This has externally the aspect of a thick-bedded sandstone, but is a peculiar micaceous and hornblendic grit, looking, when fractured, precisely like some of the old hornblendic and micaceous slates. Beyond this point, and just at the North end of the gap, there is a considerable mass of *Primal white sandstone*, forming a stone-slide or talus. In the North-west flank of the ridge, the sandstone may be seen in place dipping vertically.

There can be no doubt that the micaceous and hornblendic slates and grits are lower members of the Primal series, in a highly altered or metamorphosed condition.

A little further North beyond these exposures of Primal white sandstone, are calcareous slates and sandstone of the base of Auroral limestone, presenting extraordinary chemical alteration. These are speckled throughout with greenish serpentine, &c., or converted into white crystalline dolomitic marble. The slaty parts contain also beautiful crystals of mica and talc.

It would thus seem that the great agent of metamorphosis in this belt has been the intense heat effused during the intrusion of the great dyke of granite which forms the main body of the ridge, and that while this has developed in the slates of the Primal series a hornblendic character, and has vitrified the pure silicious sandstone, it has dolomitised the adjacent magnesian limestone, and in these and the contiguous slates has developed the serpentine, silicate of magnesia, and, in fine, the talcose and other magnesian minerals which so greatly abound on both flanks of this remarkable igneous axis. Near the centre of the Gap there occurs a considerable mass of this dolomite, and of serpentine marble and slate, which may be explained by merely regarding the ridge as a double anticlinal flexure, including near its middle a small fold or synclinal trough of the Auroral limestone.

There can be little doubt of the presence of two chief lines of eruptic matter, each composed principally of granitic rock.

On each side of these, and therefore between them, are *stratified* serpentinous beds, with various associated magnesian minerals and dolomitic limestones. It is probable, therefore, that there exists between the two granitic dykes a synclinal fold or squeeze of the Auroral limestones, which have undergone alteration and impregnation with serpentine and other minerals, as on the outside of the dykes they unquestionably have.

Near to each of the granitic belts we meet the massive gneiss in places much altered, and some of it impregnated with serpentine or converted into it. The bedding and internal stratification of much of the massive serpentine and serpentinous gneiss is too obvious to be doubted.

Upon each external flank of the ridge there occurs a belt or outcrop of the Primal sandstone, much injected with granitic matter, but still an unmistakable sandstone. The Primal slates are converted, not into but towards a gneiss, with specks of fine crystalline hornblende and mica, mingled with the granules of sand.

The belt on the S.E. is seen at the river's edge with a flattish anticlinal roll in it. The rock here weathers a reddish brown. It is a coarse sandstone, very hard, and injected with felspathic granite, some of which seems to be segregated. This outcrop, ten feet above low-water-mark, is smooth from erosion, and exhibits the feature called Rochés Moutonnais in Switzerland.

Two views may be entertained of the geological origin of the serpentines and associated magnesian minerals: one, that they are altered forms of the magnesian silicious limestone of the base of the Auroral series; the other, that they are true igneous injected materials.

The fact that one zone of these minerals is on the flank of the ridge, and seemingly outside of the Primal rocks, is friendly to the first of these hypotheses; but two other belts of the serpentine occur nearer the axis of the ridge, amid the true gneiss, and with granitic injected rocks near.

If we suppose that the whole uplifted zone embraces a compressed synclinal fold of the Auroral limestone—and the structure of the hill strongly indicates this—we may impute the magnesian minerals in part to the metamorphosis of the magnesian calcareous rocks.

The serpentinous rocks even of the more central parts of the ridge exhibit a sort of stratification, and this implies that a portion at least of the material called serpentine here, was originally a sedimentary rock, but altered, the transformation consisting, most probably, both in a segregation of its own elements and an intrusion of true igneous mineral matter.

Beyond the North side of the gap of Wolf's Hill, for about three-fourths of a mile, no exposures are seen; we then enter upon a series of undulations or flexures in the limestone, which continue with but little interruption to Martin's Creek, where, as already stated, the slaty limestone and slate of the Matinal argillaceous limestone (Trenton limestone) formation are admirably exposed. This part of the section displays the following conditions:—

1. For ¾ mile North of gap no exposure; then at limekiln, magnesian limestone, dip North 85°.
2. At 200 yards we have South dip, which continues until,
3. At 500 yards, we have North dip, about 70°. Then,
4. At 600 yards, we have South dip.

5. At 800 yards North, dip 60°, which continues to

6. 1000 yards, where we meet South dip about 50°, becoming more gentle, 40°, 30°, and 20°.

This low South-dipping flaggy limestone continues exposed along the river-shore, until it is seen gradually to turn over into a North dip at the great bend of the river (convex to the West). This is a beautifully regular broad anticlinal.

The rocks of the Northern flank of the axis are well seen at the Mineral Spring Hotel, five miles north of Easton.

7. Passing about one mile *very obliquely* across the strike, without any exposure, we come upon another broad anticlinal of the limestone.

Here are two limekilns. The rock of this axis is dark-blue and argillaceous, and more thin-bedded and slaty than the preceding, and is greatly cut by cleavage. This, in its upper beds, has the aspect of the Trenton limestone.

A little further on (500 feet) we come upon the Matinal argillaceous limestone (*Trenton limestone*) in a high escarpment on the North side of Martin's Creek. The dip of the rock is about 30°, but rolling, and the cleavage nearly horizontal. The mass consists of calcareous blue slate, with courses of blue argillaceous limestone and fissile blue slate of very even texture. This latter has the smooth cleavage and nature of roofing or writing slate. Here occur many Trenton fossils. *The whole thickness of the formation exposed cannot be less than* 150 *feet;* and there is no doubt a portion of it not visible.

Anticlinals.—From what has been noted above, it appears that there are four anticlinals actually discovered between the first exposure of the limestone and the margin of the slate, and assuming one in the interval between the flank of Wolf Hill and this first exposure, we may put down five anticlinals.

Several anticlinal flexures are discoverable in the limestone belt where it is intersected by the Lehigh River, between Allentown and the margin of the formation. Some of these are compressed South-east-dipping folds, others more open curves of the normal type. From below Allentown to within two miles of Easton, the Lehigh flows near the base of the South Mountains, apparently in the trough of the first synclinal flexure. The general dip of the limestone, as it here rests against the foot of the Gneiss Hills, is not inverted but steep towards the N.W.

I have already alluded to the occurrence of strata of *oolitic* limestone near Allentown. These are to be seen near the bridge which here spans the Lehigh.

At Porter's Quarry, one mile and three-fourths below Easton, the following structural features may be noted in the limestone—

Dip of the strata, 45° to N. 25° W.

Dip of main joints S. 45° E.

Dip of cleavage-planes at right angles to bedding.

Dip of second or great smooth joints, 85° to S. 40° W.

CLEAVAGE IN THE REGION OF THE DELAWARE RIVER NEAR EASTON AND THE SOUTH MOUNTAINS.

No district in Pennsylvania, nor indeed in the Middle States N.W. of the general South-eastern boundary of the Appalachian Valley, displays the cleavage structure in the rocks so conspicuously and pervasively perhaps, as the country between Easton and the Delaware Water-Gap. The whole belt of rocks from Easton to beyond Stroudsburg—and this includes nearly all our formations from the Primal to the Vergent—is remarkable for the amount of the cleavage fissures which everywhere, in nearly parallel direction, intersect the more argillaceous and calcareous masses. Even in the belt of anticlinal and synclinal ridges called the South Mountain (locally, the

Lehigh Mountains), this feature, so curious in a scientific point of view, and practically so important, prevails very extensively.

Commencing the following brief sketch of the phenomena with this Southern zone, it will be well to call attention first to the cleavage in the Auroral limestone of the synclinal troughs exposed on the Delaware south of the mouth of the Lehigh. Here, as the Section will show, the cleavage in the limestone, which, from the extreme thinness of the Primal series, is almost the only Palæozoic mass preserved, observes, very generally, the law prevalent throughout all the South-eastern Appalachian region. It exhibits a *steep South-easterly dip;* but it is interesting to note that the strike of the cleavage seems not to coincide with either the strike of the Palæozoic strata to which it belongs, nor yet with the strike of the previously disturbed and somewhat unconformable syenitic gneiss.

In the Auroral limestone of the synclinal before us, the abundance of the cleavage-planes is decidedly less than in the Matinal slates of the Kittatinny Valley, a fact quite in accordance with the very general observation that these massive magnesian rocks, like all our massive thick-bedded homogeneous strata, excepting the purely argillaceous ones, have been far less affected by the transforming igneous influence derived from within the crust, than the ancient mud-rocks. Everything else in the geology of this disturbed and contorted zone, leads us to infer that here the metamorphic action was at a maximum, or was at least more intense than in the tracts further north. The higher degree of cleavage in the slate rocks further up the Delaware must, then, be fairly attributed to some special relations between the mineral natures of the strata, and their susceptibilities to assume this peculiar structure. Into the consideration of this somewhat subtle connection I shall enter in another place, where an attempt will be made to give a theory of cleavage and metamorphic action generally.

The strike of the Gneiss in this district varies from N. 50° E. to N. 45° E.

That of the Palæozoic strata is generally about N. 65° E.

But the strike of the cleavage-planes of the latter—the limestone—is frequently, by several degrees, more E. and W., though sometimes it is very nearly conformable to that of the strata.

In the greatly disturbed and altered igneous and metamorphic mineral axis N. of the town of Easton, there called Chestnut Ridge, and in New Jersey, the Marble Mount, the Auroral magnesian limestone highly affected by contact and intrusion of injected or infiltrated volcanic matter, displays the cleavage structure very conspicuously. The talcose and serpentine rocks, whether we regard them as altered forms of the magnesian limestone or not, are unquestionably stratified rocks, and even these display the cleavage structure. Disturbed as the bedding is in this much-convulsed anticlinal belt, the cleavage-planes, though far from regular, and often nearly perpendicular, have a prevailing steep South-eastern dip.

CHAPTER III.

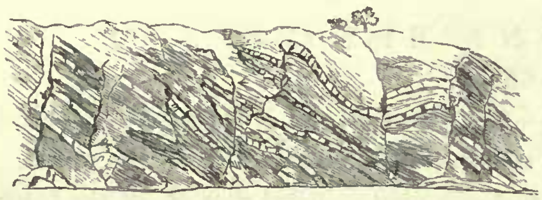
MATINAL SLATE OF THE KITTATINNY VALLEY, BETWEEN THE DELAWARE AND SCHUYLKILL.

Boundaries.—It has been already stated that the Northern side of the Kittatinny Valley is occupied almost exclusively by the Matinal newer slate spread out in a broad belt like the limestone, by a series of anticlinal and synclinal undulations. The Southern margin of this slate was traced from the Delaware to the Schuylkill in defining the Northern limit of the limestone. The Northern boundary coincides very nearly with the Southern slope of the Kittatinny or Blue Mountain, the junction of the upper layers of the slate with the lower beds of the Levant grey sandstone being in some places lower, in others higher, on the mountain-side.

Geological Structure of the District.—By a reference to the general Sections, Nos. II. and III., it will be seen that throughout this portion of the valley the anticlinal flexures in the slate have less of the closely-compressed or inverted form than belongs to those S.W. of the Schuylkill. On the mountain-side of the belt especially, the more open or normal style of undulation is everywhere discernible near the foot of the mountain. The Kittatinny Ridge itself, from the Delaware to the Schuylkill, exhibits no inversion of the strata, the dip being at a moderate angle towards the N.W.; it is therefore but the Northern abutment of a huge normal arch.

Further to the S.W. the rocks of this mountain, and the ridges N.W. of it, are more nearly vertical, and in some places, as at the Susquehanna, actually overturned beyond the perpendicular; and connected with this greater steepness, we observe in the corresponding portions of the Matinal belts of the Great Valley a proportionately greater amount of compression and obliquity in the flexures, and therefore a more general prevalence of the South-eastern dips.

FIG. 31.—Close foldings in Matinal Slate, Harrisburg.



Within the limits of the Slate tract, the Auroral limestone is lifted to the surface in two localities by anticlinal flexures, but it is very evident that in other places this formation lies at no great depth, though concealed by the overlapping slate. One of these insulated outcrops of the limestone is at the Delaware River in the Little Valley of Cobus Creek; the other in or near Kreidersville, not far from the Lehigh.

The Cobus Creek Belt of the Matinal limestone is but the South-western termination of the long and narrow anticlinal of the Valley of Paulinskill in New Jersey. With the gradual subsidence of the axis, the limestone contracts to a point, and passes under the slate about two miles West of the Delaware. The flexure is nowhere very steep, even the North-western dip not exceeding 45°. On the Delaware the belt is rather more than one mile in width, the Southern limit being somewhat more than half a mile below the mouth of Cobus Creek. This limestone produces excellent lime, and is quarried to some extent. The most Western quarry is near the Tott's Gap Road.

The much smaller outcrop of the limestone near Kreidersville is about two and a half miles

North of the Southern edge of the slate. Its extent is limited. The dip there is very irregular, but the predominant direction is Eastward about 40°, and the strata seem to have been contorted and broken by a more than usual degree of subterranean action, for the rock is filled with intrusive veins of white quartz of all dimensions up to a foot in width. This little tract of the limestone, so far within the general margin of the slate, is therefore most probably the result of a local dislocation on an anticlinal, rather than the effect of a regular unbroken flexure.

This limestone is quarried and converted into lime on the spot for agricultural use.

Between the Northern edge of the limestone tract, and the anticlinal of Cobus Creek, the slate exhibits an apparent general dip to the S.E., but much of this is due to the cleavage fissures, all of which incline in that direction. It is probable that this belt constitutes one wide synclinal trough with lesser undulations in the middle of it. Along its Southern border runs a chain of slate hills, traceable with interruptions to the Lehigh. At the junction of the two formations the limestone displays a gentle dip North-westward, passing under the base of these hills. Near this line of contact there occur in the slate several calcareous layers, some of which approximate to the composition of an impure limestone. Some of these contain casts of fossils of the usual characteristic species, but they are imperfectly preserved. Veins of white rhombic carbonate of lime, with white quartz, occur in this line in several localities; and further Northward in the slate tract, injections of white igneous quartz are not unfrequent. In the vicinity of Martin's Creek, and again near Kreidersville, fragments of igneous quartz are numerous in the soil, and some of these are of large size, showing the veins to be one foot and more in thickness.

Slaty Cleavage.—A remarkable peculiarity in the position of the cleavage-planes is visible over quite a wide belt in the centre of the Appalachian Valley, all the way, indeed, from the Delaware to the Lehigh, and extending even N.E. and S.W., beyond the rivers. It is that of a near approach to horizontality. This flatness of the cleavage-dip is well seen on Martin's Creek, at the junction of the Matinal limestone and Matinal black slate, and characterises, I believe, the entire outcrop of these two rocks in their range South-westward to the Lehigh. But the zone over which it prevails is even broader, for the same flat cleavage is met with to the N.W. of the contact of the two strata over a space of at least two or three miles. It may be seen along Martin's Creek for nearly three miles above its mouth. Further to the S.W. we behold the cleavage with this gentle dip, or even flat position, to the N. of the villages of Nazareth and Bath, and near Kreidersville. Indeed it occurs in various places, though along belts less continuous and broad, the whole way to the Southern base of the Kittatinny Mountain.

About eight miles from Easton, on the watersheds between Martin's Creek and Richmond Creek, the Matinal slate exhibits both cleavage-planes and transverse joints in remarkable regularity, but directed to rather unusual quarters of the horizon.

Roofing-Slate Quarries near Delaware Water-Gap.—The portion of slate belt included between the Delaware and Lehigh presents several localities of excellent roofing-slate. While the formation, as a whole, contains much coarse arenaceous rock, and even some beds of conglomerate, certain strata, especially in the lower part of the mass, possess the qualities of the roofing-slate of commerce.

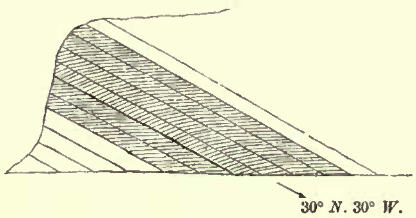
That part of the formation which contains the roofing-slate lies in a narrow zone, distant from one to three miles from the Kittatinny Mountain, running from a point in New Jersey a few miles E. of the Delaware Water-Gap, across the Delaware and the Lehigh, to a few miles W. of the latter river. It is, however, only in a very limited number of places within this belt that the rock presents that fortunate union of conditions which must exist to produce good slates. Not only must the rock be sound, uniform, and compact in texture, easy of cleavage in one direction, and tough in every other, and free from any bands (called ribbons) containing sulphuret of iron, which cause its rapid decomposition, but it must lie in a favourable manner for being quarried, with a stream of water passing over the stratum to preserve it moist, and cause it thereby to split with ease and regularity.

These conditions are very happily combined in the two quarries, which are at present wrought near the Delaware Water-Gap. That on the West side of the Delaware, worked by the Pennsylvania Slate Company, presents some very interesting features.

The *Quarry* at present is in the form of a beautiful amphitheatre or circle of cliffs, about 100 feet in diameter, and at least 60 or 70 feet high.

The strata, fine bluish slate with ribbons of bedding, dip about 30° to N. 30° W., with remarkable regularity. In all the portions below a certain plane, apparently that of a slip or fault, the cleavage is very nearly horizontal; but immediately above that plane, the cleavage-planes of the first course curve down steeper and steeper towards the S.E., or S. 45° E., and in all the still higher ones the tendency is to a S.E. dip, but only very gently, except in the North-western parts, where it is more obvious. The annexed Sketch shows the cleavage in its different phases.

FIG. 32.—Cleavage in Slate Quarry, Delaware Water-Gap.



The texture of this slate, in the absence of any defining fossils, suggests that it may belong to the Utica Slate Formation, and it is quite conceivable that an axis at this distance from the outcrop of the Levant Sandstone of the Kittatinny Mountain may lift the Matinal Slate to the day, but this needs confirmation.

The true stratification of the rock is only detected here by the difference in colour caused by numerous very thin layers, from a few lines to an inch or two in thickness, traversing the rock in bands parallel to each other, and at various distances, not generally exceeding two feet. These ribbons denote the direction of the dip of the strata, being seams of a somewhat different composition from the rest of the mass. Between each two of these ribbons the layer of slate is homogeneous, or of uniform texture and composition; but a difference in the quality of the slate on the two sides of one of these thin layers is quite common.

When we examine a new surface of the slate, the usual and permanent colour of which is a dark bluish grey, the hue of these ribbons is nearly black; but on exposure to the atmosphere, they show after some time signs of spontaneous decomposition, and display a whitish efflorescence, which indicates that this part of the slate contains the sulphuret of iron. These ribbons are therefore carefully excluded from the slates when they undergo the operations of cleaving and trimming, in their preparation for the market.

At one place in the quarry, the dip of the strata, as indicated by that of the ribbons, is towards the W.N.W., at an angle of about 30°. In the same part of the quarry the dip of the *cleavage-planes*, or in other words, of the slates, is towards the South, and at an angle of nearly 50°. Here, however, is the same dislocation or *fault* traversing the quarry as in the spot first described. This is a slide of one part of the stratum upon the other, and is from six to twelve inches wide, being filled with white calcareous spar and fragments of slate. The rock below it has not only a different actual dip from the portion of the stratum above it just alluded to, and a different direction also in the cleavage of the slates, but a different quality in these slates themselves, those beneath being much superior to those over the dislocation. From this lower part of the quarry, nearly all the roofing and writing slates are derived. The best school-slates are got from belts that lie directly beneath the sparry seam or fault. The direction of the cleavage-planes in this portion of the mass is nearly horizontal, while the planes of stratification dip towards the N.W., but at a very moderate angle. The difference between the directions of the cleavage-planes above and below the fault, renders it possible that the dislocation and slide in the stratum took place after the mass had acquired this remarkable tendency to cleave in a direction oblique to the stratification; for had the cleavage originated subsequently to the disruption of the rock, we ought to find it maintaining the same direction, and observing the same features on both sides of the fault. These facts concerning the change in the quality and the position of the slates caused by the dislocation, indicate how numerous and minute the circumstances are which must be attended to by those who enter on the business of quarrying this rock.

About a mile S.E. of the quarry just described, another has been opened, but it has not been vigorously wrought. That on the opposite side of the river, in New Jersey, is worked, though rather inactively, notwithstanding the excellent quality of the roofing-slates procured in it.

In the hills along Martin's Creek, about four miles above its mouth, are indications of good roofing-slate.

Slate Quarries near the Lehigh Water-Gap.—The only other considerable quarry, besides those near the Delaware, in operation within the slate-belt of this part of the State, is the Union Slate Quarry, about one mile W. of the Lehigh and about nine miles N.W. of Allentown. The most remarkable feature here is the parallelism of the cleavage-planes of the slates to the plane of the stratification. The dip is towards the S.S.E., at a somewhat variable angle, averaging 15°. Owing to this coincidence of the cleavage with the stratification, the surface of the slates is slightly undulating. They are esteemed well adapted for roofing, but being hard, they are not sold for writing-slates. The hardness of the rock in this quarry I attribute to the high temperature originally imparted to it by a mass of intruded quartz, which has entered it from a deep source within the earth. The force which injected this material has heaved up a portion of the strata into the form of a small anticlinal elevation in the quarry, and has in other respects deranged the dip of the rock.

The slate quarries around the town of Slatington are situated near the base of the Kittatinny Mountain, about two mile S. of the Lehigh Water-Gap, embraced in forty acres of land, owned by a company. Five quarries are now opened, called the Washington, Trout Creek, Franklin, Bangor, and Douglas. The first is the largest, 120 feet from base to top, and 300 feet exposure. The Douglas is the smallest, 60 feet high, with a front face of 75 feet; from this school-slates are taken; and from the other four, roofing-slate.—(*Mining Magazine*, 1856.)

There is a small quarry which has been occasionally worked, lying about one mile and a half W. of the town of Nazareth. Roofing-slate was also formerly procured on the East side of the Lehigh, near Kreidersville.

It is by no means improbable that other points along the same belt of country would reward diligent search by presenting eligible situations for quarries.

In the neighbourhood of Nazareth, which is on the line dividing the slate from the limestone formation, a material is procured, which answers well the ordinary purposes of *black paint*. This appears to be simply a more than usually carbonaceous, black, and soft variety of the Matinal black slate, occurring near the base of the formation a little above its contact with the limestone. It occurs also further E. on the Bushkill, and has been found likewise on the Union Canal, in a corresponding situation in the stratum. It requires to be ground in a drug-mill, and levigated in troughs, by passing over it a stream of water. Thus prepared, it constitutes, when mixed with oil, a very excellent pigment for the exterior of houses, fences, and other structures exposed to the weather.

Evidences of Erosion of the Surface.—In no part of the Kittatinny Valley are the evidences so striking of an energetic rush of waters across the surface from the Northward, as in this region between the Delaware and Lehigh. Transported boulders of sandstone and conglomerate traceable to the Levant rocks of the Kittatinny Mountain, and to the Vespertine and Seral conglomerates still further North, strew the soil in almost incredible numbers. This drift appears to be most abundant opposite the gaps and depressions in the Kittatinny Mountain.

Hydraulic Lime.—Some of the calcareous layers in the inferior portions of the Slate formation seem by their composition to be well adapted for producing an excellent variety of hydraulic cement. A manufacture of this article was begun a few years since on the Eastern side of the Lehigh, above Siegfried's Bridge, the rock being near the junction of the slate and limestone. The cement made proved to be well suited to the purposes of hydraulic architecture.

Slate Hills.—In pursuing this slate formation Westward from the Lehigh, we find towards the line between Lehigh and Berks counties, a large area of country very uninteresting to the geologist from its sameness. An endless succession of slate hills, containing rocks of the same character as those already described, leave little to say concerning this region. About the head-waters of Antelanna, or Maiden Creek, those hills attain a height almost entitling them to the name of mountains.

From the neighbourhood of New Tripoli, westward, the slate-hills and ridges increase in height: some of their more conspicuous peaks, visible from a great distance, have received the names of Spitzberg, Round Top, &c. The ridges passing across the line into Berks County range near the churches N. of Schaffer's Tavern, and rise E. of Round Top and Spitzberg, to nearly the same elevation, being entirely cut down by denudation in the valley of Maiden Creek and Pine Creek. W. of the latter stream they again rise into high points, and a ridge of great height continues Westward, until it almost unites with the Blue Mountain N.E. of Hamburg. Above the mouth of Pine Creek, and near the Church, a little above the Old Union Furnace (Reagan's), is a slight calcareous band in the slate, which has been tried for making lime, but without much success. Some of the limekilns here are upplied with stone brought across the mountain from the Pre-meridian formation. Indications of calcareous strata appear in the low ground near the foot of the mountain; but the nature of the country is such as to offer scarcely any good exposures of rock in place. Lime has become much prized by the farmers in the slate region as a manure, and is extensively prepared by many who bring the limestone with great labour over a hilly road from the neighbourhood of Kutztown, ten or fifteen miles.

Red Slate.—About Klinesville, seven miles Eastward from Hamburg, we find a band of red slate, which seems to die out a little to the Eastward of that place. As we shall hereafter see, this variety is of very common occurrence in the formation further Westward. W. of the Schuylkill, and along the Tulpehocken Creek, alternations of red slate, with the dark-grey slate, are very common, and seem to be connected with the calcareous bands, which are more common there than in the district before us.

Band of Limestone.—About four miles N.W. from Kutztown, a little N. of Saconing Creek, at Kemp's Mill (Kiemer's on the County Map), there is a band of limestone in the Slate formation, which is quarried on the farm of Mr Rocher. It is seen in the quarry about 20 feet in thickness, mixed with slates, some of the strata being very thin, others one foot or more in thickness, the dip about 30° S.S.E. It is used for burning into lime for a manure. The same band is also seen at Sontag's, above Lesher's Mill, near the mouth of the Saconing, and at other places further Westward ; but it is not known to extend Eastward much beyond the quarry at Kocher's. This is evidently a prolongation of a calcareous band, which we shall have occasion to notice as occurring at Winter's, on the West side of the Schuylkill.

At Hoch's, two and a half miles West from Kutztown, in the Southern edge of the slate, there occurs well-crystallised Arragonite.

CHAPTER IV.

AURORAL LIMESTONE OF THE KITTATINNY VALLEY BETWEEN THE SCHUYLKILL AND SUSQUEHANNA RIVERS.

The Northern boundary of the Auroral limestone from the Schuylkill to the vicinity of Stouchtown is very irregular, in consequence of the presence of a number of anticlinal undulations, which cause the limestone and slate to interlock by a succession of long narrow tongues, or tapering belts. I shall therefore not attempt a minute tracing of the line of separation, but refer to the Geological Map for a general exhibition of its course. After many undulations in the vicinity of the Tulpehocken, the line passes about two miles Northward of Stouchtown, in a more nearly straight direction West-south-westward, ranging half a mile N. of Myerstown, and thence parallel with the turnpike leading to Harrisburg, preserving a nearly uniform distance from it of about half a mile, as far as Hummelstown. Crossing the Swatara Creek or River north of this village, it extends parallel with the stream for nearly two miles ; and about a mile W. of the point at which the turnpike road crosses this, it intersects the turnpike road, and thence ranges a little S. of this to the Susquehanna at Harrisburg. North of the Southern Slate Ridge, which forms the Northern boundary of the main belt of limestone from the Swatara to the Susquehanna, there is a narrow strip of the limestone extending Eastward from the river below Harrisburg. This lies on both sides of the turnpike road near the Dauphin County Poor-house, where it is but little more than one-fourth of a mile broad. Between it and the chief mass of the limestone to the S. there is here a narrow belt of the slate, which, widening Eastward, merges into the general slate tract near the Swatara below Hummelstown.

Trap Dyke.—About four miles W. of Reading there occurs a *dyke of trap*, crossing the limestone Northward from the Primary hills. It may be seen on the turnpike a little E. of Sinking Spring, and thence down the Cacoosing Creek, showing itself on the W. of the stream, and crossing the Tulpehocken at the mouth of Cacoosing, where the trap-rock in place is finely exposed near Van Reed's Mill. Thence still further N.E. the boulders of trap appear on the slate near Epler's ; but the dyke does not seem to reach so far N. as the Schuylkill.

Iron Ores.—Brown iron-ore lies on the surface in many places Westward of the Schuylkill, especially about Cacoosing and Sinking Spring ; though for many years sufficient search seems not to have been made for it. More recently considerable quantities have been mined, and sent to the Schuylkill at Reading. One mine is situated about nine miles from Reading, and about a quarter of a mile S. of the turnpike. The ore was disseminated through clay. It is of mixed quality, though much of it seems to be capable of making a good iron.

S. of the road from Womelsdorf to Stouchtown, ore is seen on the surface ; and about half a mile S. of the place last named it has been mined. This ore lies on the rising ground S. of the Tulpehocken, on the limestone, where that rock is very silicious and cherty. The ore is of a hard, compact quality, much of it being found in large solid masses, some of which weigh more than 100 pounds. It has the external aspect of a cold short ore. There are indications that iron ore might be found at several points from Womelsdorf S.W. along the Southern margin of the formation.

CHAPTER V.

MATINAL SLATE OF THE KITTATINNY VALLEY BETWEEN THE SCHUYLKILL AND SUSQUEHANNA.

THE upper portion of this formation, as exposed on the West bank of the Schuylkill below the mountain, for several miles contains some thick bands of tolerably compact sandstone, interstratified with the slate. The more solid beds are in several places quarried, and have been used in the construction of culverts, bridge abutments, &c., on the Reading and Pottsville railroad.

About two miles below Hamburg these sandstone strata become less frequent, and the slate more uniform, though it is still very silicious. Further down the river the slate becomes thinner in its laminæ, and darker coloured, some of the bands bearing a resemblance to roofing-slate, though none of it has a sufficiently regular cleavage to be valuable as such.

At Althouse's Bridge, as already observed, occurs the point of junction of the slate with the limestone.

We find no calcareous bands of any importance in the railroad cuttings near the river, the excavations being mostly through the harder projecting ridges of silicious and slaty rocks; the limestone, if its narrow bands reach the river, being usually in a position occupied by low ground or diluvial soil, owing to its greater tendency to decomposition and denudation. Nearly Westward from Shoemaker's (about 12 miles above Reading), we find on the high lands W. of the river a band of limestone 20 or 30 feet thick, in thin layers, including some slate. This is quarried at Winter's, and other places in the neighbourhood, for burning into lime for manure. Thence it extends Westward towards the head-waters of Irish Creek, and is probably the same band as that which is quarried at Straus's, Mast's, Himmelberger's, &c., crossing the Northkill near Hawk's Mill, and passing N.W. of Bernville to the Northern edge of the main limestone formation near Kauffman's, three miles N. from Stouchtown. N. of this band of calcareous slate are some veins of red slate, but not of great thickness.

On the Main North Kill, perhaps half a mile above the Little North Kill, there occurs a thick bed of limestone dipping 35° S., exposing an outcrop of more than 300 feet in breadth. The composition of the rock is peculiar, and well deserves the attention of the geological inquirer as suggesting some important theoretical inferences. It is a true calcareous *conglomerate*, composed of pebbles of the Auroral magnesian limestone firmly cemented by a limestone paste. Some of these pebbles are but imperfectly rounded or worn upon their edges, but the greater proportion of them are apparently completely water-worn. This stratum extends several miles, appearing more than two miles W. of the Little North Kill. It is not the only instance in the Auroral series of a conglomeritic limestone consisting of pebbles derived from the inferior part of the formation, of which it is itself one of the upper members. Near the little village of Hope, in New Jersey, there is a similar stratum not far below the junction of the limestone and slate. It is obvious, from the occurrence of so thick a bed of limestone pebbles, that at the period of the formation of the stratum, the previously-deposited limestone must not only have been already solidified, but sufficiently uplifted to be exposed to destructive currents. Each such stratum has been evidently the result of a paroxysmal movement, probably of the nature of an earthquake, not sufficiently energetic permanently to elevate or incline the newly-formed sedimentary mass, or to interrupt the general progress of the deposition, yet violent enough to set the waters into active motion, and thus break up and strew afresh in form of pebbles the more exposed upper strata.

The limestone matter which occupies the interstices between the pebbles may have originated either from materials in a state of suspension in the waters at the time of the sudden movement, or more probably as a wash from the newly-deposited and still soft and pulpy carbonate of lime of other tracts still submersed.

One of the most interesting circumstances attending this conglomerate is the terminal position which it occupies in the formation. It is at or near the higher limit of one of the thickest and most widely-expanded limestone deposits of the continent. The violent agitation of the sea-bed which it indicates must therefore have been that which preceded or attended the extensive revolution in the physical geography in the Appalachian ocean, by which the growth of the Auroral calcareous sediments, their wide shell-beds, and vast coral reefs, were for ever suspended, and a new state of the waters established, hostile to nearly all the old forms of life, but friendly to others freshly created, and with new adaptations.

This revolution, as the geological exploration of the Palæozoic Basin of the continent shows, banished the conditions favourable to the deposition of lime from nearly its entire area, and substituted a state of things compatible only with the precipitation of mud and sand, to endure as long, seemingly, as the immense antecedent period of the calcareous depositions. It could have been nothing short of a total reconstruction of the bed and shores of that ancient sea ; and from various evidence, the nature of the revolution was partly a sudden, partly a gradual, stupendous lifting of the sea-bed from comparatively deep to shoal water.

Near Wagner's, four miles Westward from Hamburg, a slight exposure of slaty limestone appears, but the material is not now used. Westward from this, four miles further, at Shartel's, eight miles from Hamburg, we find some considerable bands of red slate, which appear to die out Eastward.

S. of Irish Creek we find steep slate hills, and a little N.E. from Bernville rises a high ridge, which is called "Scull's Hill," and which is prolonged past Bellman's Church towards the Schuylkill, near the mouth of Irish Creek. This ridge is chiefly slate, with some thin bands of silicious rock, all dipping steeply S.S.E. To the S. of this ridge, about the head of Plum Creek, we again find calcareous strata in the slate in the neighbourhood of Himmelberger's Mill, and S. of this a red slate, interspersed with the bands of dark and yellow slate common to the formation. From this point South-eastward are barren slate hills (containing red slate bands), with a few sandstone strata, extending hence to the Northern border of the limestone near Reeser's Mill, six miles N. from Reading.

On the road from Reading to Bernville we pass from the limestone to the slate, about one mile S.E. of the bridge over the Tulpehocken, or about five aud a half miles from Reading. Hills of the slate continue along the bank of Tulpehocken to Heister's Mill, near which are beds of limestone mixed, and alternating with slate ; and above Heister's the calcareous bands increase in frequency and thickness, varying from a few inches to 50 or 60 feet in dimensions. The dip here is much confused and undulating ; but this condition continues for a very short distance, the general dip being 45° to 70° S.S.E. Red slate occurs abundantly on both sides of the calcareous belts. The main calcareous band extends Eastward to the neighbourhood of Bern Church, and disappears a short distance beyond it. These calcareous beds near the base of the slate probably represent the Auroral argillaceous limestone.

From Heister's on the Tulpehocken to a mile beyond Bernville, on the road to Rehrersburg, we find thin bands of limestone in the slate. All these bands, when of sufficient thickness and purity, are quarried in many places for burning into lime, which is used as a manure; but the lime produced from them is not considered so good for building as that from the main limestone formation on the S.

Crossing from Womelsdorf to Bernville, we pass first a belt of the slate, about half a mile wide, then limestone a quarter of a mile in width, dip 30° to 45° S.S.E.; then a slate ridge, two miles from Womelsdorf. Half a mile N. of this are some bands of limestone, but slate prevails as far as Tulpehocken at the mouth of North Kill Creek. Near the Tulpehocken we find many belts of red slate.

From the mouth of North Kill up the tow-path of the canal, dark and red slates are chiefly apparent for about two miles, then bands of slaty limestone 10 to 50 feet thick. These latter continue mixed with dark and red slates to a little above the old forge (formerly Ege's), where the slate becomes more and more mixed with calcareous strata. At about half a mile above the forge the slate ceases, and the limestone continues to Womelsdorf, though somewhat thin and slaty, opposite the end of the slate hill half a mile N.E. from that town. The dip about Bernville is steeply S.S.E. 60° to 80°, diminishing Southward towards Womelsdorf to 30° and 40°.

From all this it would seem that the slate suddenly widens out W. of the Schuylkill by deflecting its Southern margin Southward, very nearly to the turnpike at Hain's Church, eight miles W. from Reading, and thence to within less than half a mile of the Primal sandstone near Womelsdorf is penetrated by belts from the wider portion of the limestone region N.W. of Womelsdorf, and that the two formations mutually pierce each other by innumerable tongues or small pointed belts, which gradually thin out, the limestone bands on the E., and the slate bands on the W. This irregularity ceases from the neighbourhood of Kauffman's, N.W. from Womelsdorf, and N. of Stouchtown, for here the limestone having spread out on the N. to its usual breadth, and the slate having contracted to a narrower range, the line of union between them, trending W.S.W., is nearly straight, and is well defined.

Near the Southern border of the slate S. of Rehrersburg, the formation embraces several bands of the red slate. Northward from that village to the base of the mountain, the only rock is the grey slate of the upper half of the formation. It appears to be destitute of any beds of limestone. The prevailing dip is to the S.S.E., and steep; in some places it is perpendicular. W. of Rehrersburg narrow bands of the limestone show themselves. One occurs on the road to Jonestown, three miles from Rehrersburg, and another about three miles E. of Jonestown.

Along the Tulpehocken the slate ridges contain much intrusive *quartz* in the form of narrow veins. Indeed, all the higher ridges of the central tracts of the valley appear to be traversed by innumerable thin injections, and to owe their elevation above the general plain to the superior resistance locally presented by these ribs of indestructible material, over that offered by the slate under the excavating action of the denuding currents. In the tracts so replete with igneous quartz, we usually find the strata dipping at a steeper angle than elsewhere, a natural consequence of the more complete folding together of the beds under the lateral compression connected with the intrusion of so large an amount of material.

Iron Ore.—About two miles N.E. of Jonestown large masses of a rough and cellular silicious *iron ore* appear upon the surface. These strew the Southern slope of a low ridge of slate, and seem to be derived from a band of yellowish and red slate of the kind very common in this neighbourhood.

Limestone.—N. of the red slate there exists a narrow band of slaty limestone, and a similar thin bed appears S. of the iron ore. About half a mile E. of Stumpstown, iron ore closely resembling that above mentioned was dug many years ago, but the supply proving deficient, the excavations were abandoned. Near this old mine occurs a calcareous and ferruginous stratum in the slate, very susceptible of decomposition; and it seems probable that this ore is derived from a somewhat similar band of rock. On the Rehrersburg road, about three miles E. from Jonestown, a little S. of a small limestone band, a small excavation was once made for iron ore, which was found in very limited quantity.

Bunker's Hill.—S. of Jonestown there is a high and rocky ridge called "Bunker's Hill," which rises steeply on the Eastern side of the Swatara, and ranges along the Southern side of the Little Swatara for between two and three miles, sinking away Eastward near the road from Stumpstown to Lebanon. Towards the Western end of this hill there is a depression, over which passes the road from Jonestown to Lebanon. East of this indentation its higher parts consist of sandstone closely resembling the Primal sandstone, though it is difficult to conceive how it can have been uplifted here. It lies in huge broken masses on some parts of the hill, and on others is more disintegrated. The Western part of the hill, next the Swatara Creek, shows none of this sandstone, being composed of curiously altered rocks, with some boulders of trap. Along the Northern and Southern bases of this ridge we find a limestone evidently very different from the calcareous slaty bands so common in this part of the slate formation. From its position and character it seems to belong to the Auroral limestone. It is visible along the Little Swatara south of Jonestown, where it is quarried, and appears to extend about two miles up that stream Eastward. On the Southern side of Bunker's Hill it is quarried on the bank of the Swatara, a little below the aqueduct, and at other places on the S. of the hills farther Eastward. On both sides of the ridge this limestone evidently overlies the sandstone. On the S. we find the limestone overlaid by slate, with some red bands; and about half a mile S. of Bunker's Hill, as we approach another trap ridge, the slate exhibits the influence of the once heated trap in its highly-altered aspect and structure.

Half a mile further S. there is another ridge of trap-rock, the interval between this and the last-mentioned being occupied chiefly by the slate, which here includes some bands of argillaceous sandstone. This dyke crosses the road from Jonestown to Millerstown, about two and a half miles from Jonestown, and terminates on the Eastern bank of Swatara, about a mile above the Waterworks. Eastward it does not extend much beyond the *Eastern* road from Lebanon to Stumpstown, and is seen abundantly on the *middle* road, S. of Little Swatara, and also on the road from Lebanon to Jonestown.

Between this Southern trap ridge and the Northern margin of the limestone, half a mile North of Lebanon, the whole space is occupied by the slate of the usual character of the formation.

North of the limestone on Little Swatara, S. of Jonestown, we find the slate in its ordinary characters; but on the N. of the town it includes calcareous bands, and also much interposed red slate. A little above the Swatara Bridge west of the town there is a quarry of the slaty limestone, the layers being from an inch to a foot in thickness, the whole dipping nearly perpendicularly. Ascending the Swatara from this point we find a band of red slate of considerable width, and others narrower, mixed with the common dark slate, which continues to nearly two miles above Jonestown, where we find calcareous strata that have been quarried and used for making lime.

About a mile further (*i. e.* one mile below Weidman's Forge) there is a silicious conglomerate 30 or 40 feet thick, an upper member of the Matinal slate. On the E. of the Swatara it forms a hill or ridge. Above this point, in the neighbourhood of the forge, we have the slate exposed along the canal bank, with a general S.S.E. dip, though in some places curiously twisted and contorted.

The Hole Mountain is a narrow ridge rising E. of the Swatara, extending nearly parallel with the Blue Mountain for four and a half miles, and subsiding Eastward before reaching the road which connects Millersburg with Pine Grove.

The included valley of Hole Creek, about one mile in width, between the two mountain-summits, contains only the Matinal newer slates, with some thin bands of very slaty limestone. In the narrow crest of the Hole Mountain we meet with massive beds of the Levant grey sandstone, dipping to the S.S.E. at an angle of 80°. The very summit itself consists of a silicious conglomerate, adjacent to which are beds of a fine-grained whitish grey sandstone. Both flanks of the ridge expose the slate. It is manifest that a steep and closely-compressed synclinal fold has here preserved the lowest of the hard Levant rocks from denudation, and formed this long narrow ridge. The anticlinal flexure connected with this synclinal occupies the middle of Hole Valley. As usual in such closely-folded synclinal flexures, the strata are much contorted near the centre of the trough. This is displayed at the Western end of Hole Mountain, near the feeder of the Union Canal, where the beds of slate are greatly crushed and twisted.

At Harper's, near the mouth of Indian Creek, five miles W. of Jonestown, limestone is quarried from the calcareous bands of the slate. These seem thicker and more abundant here than they usually are in this range. The calcareous layers are, however, only from one to six inches in thickness, being much mixed with slate. They yield a lime of inferior purity. Two miles S. of Harper's, other calcareous strata appear, which are probably a prolongation of those a little N. of Jonestown, while those at Harper's, on Indian Creek, may belong to the strata on the Swatara about two miles above Jonestown. It is, however, very difficult to trace accurately such very thin bands of limestone through a country composed of friable slate, and where the exposures of the limestone are comparatively rare and ill defined.

On a singularly sharp and abrupt slate hill near the creek above Harper's, there occurs a peculiarly fine-grained compact rock, resembling a hone-slate or *novaculite.*

About two and a half miles N.W. from Harper's, a little iron-ore was once mined. A shaft was sunk, eighteen or twenty feet, through earth and rotten slate, to a peculiar conglomerate rock, containing innumerable rounded masses of sulphuret of iron, the cement being calcareous matter. This rock was said by the miners to be two or three feet thick, and much decomposed on the outside. Below it lies the ore, which is evidently derived from the decomposition of the calcareous and ferruginous stratum above, but which is probably too highly impregnated with sulphur to be usefully employed in a furnace.

A very similar region to that above described, embracing the ordinary Matinal slate, interspersed with narrow bands of calcareous rock, ranges Westward, and is well seeu on Monday Creek, from the Swatara to the mountain. The calcareous bands appear both on the S. and N. of the road from Jonestown to Harrisburg, one being quarried near the creek, about half a mile N. of that road. Further up the creek, about a mile from the mountain, there is a calcareous stratum a little below the furnace. This is visible near a spring in low ground, but is not used; further Eastward, however, it is more apparent. This is probably the same band as that seen in Hole Valley, and which ranges along the Southern base of the mouutain, at the distance of from half a mile to a mile from it. It is doubtless a prolongation Eastward of the same calcareous stratum seen to the Westward of the Susquehanna, near the mountain. It passes not far from Linglestown, and is visible in occasional spots throughout this range Eastward as far as Hole Valley. Indications of other calcareous strata in the slate are apparent near the mountain, much further Eastward, but do not seem to be connected with any important beds of limestone. These calcareous beds are seldom fossiliferous.

From Monday Creek Westward to the Susquehanna, the same upper portion of the Matinal slate presents precisely the same features as further Eastward. The hill to the Eastward of Harrisburg contains a conglomerate, with strata of slate aud sandstone, much resembling that noticed as occurring in a hill E. of the Swatara, above Jonestown. The slate hills S. of the narrow belt of limestone which passes near the Dauphin County Poor-house, and along the turnpike from Harrisburg towards Hummelstown, have been sufficiently noticed already.

CHAPTER VI.

AURORAL LIMESTONE OF THE KITTATINNY VALLEY BETWEEN THE SUSQUEHANNA AND THE MARYLAND STATE LINE.

Along the South-western bank of the Susquehanna, we find the Southern margin of the limestone overlapped by the red shales of the *Mesozoic or Middle Secondary series*, about two miles below New Cumberland, at the mouth of the Yellow Breeches Creek, the limestone rising in a moderately elevated cliff near the river. Near its contact, it has derived a reddish tinge from the overlying red shale ; but a little further N., in Musser's Quarry, it loses this stain, some layers presenting the aspect of a fine white marble, which, if thick enough to work, would be a valuable rock. The prevailing dip of the limestone here is towards the S.S.E., at an inclination of 30°—35°. Near the mouth of the creek, the limestone contains a narrow belt of slate, visible occasionally for several miles up the stream, and extending, indeed, along the Southern border of the formation, the whole way to Maryland. Above New Cumberland, the limestone is discernible along the water's edge, preserving its usual character, but exposing changes of dip implying the existence of an anticlinal fold. Immediately above, the dip diminishes to 15° S., and gradually grows less, until at a little more than a mile below the railroad bridge at Harrisburg, the strata become horizontal, indicating this as the position of a flat anticlinal arch. North, for about a fourth of a mile, the strata incline Northward, at an angle not exceeding 20°. We then find a flat synclinal axis, beyond which, for three-quarters of a mile, to the bridge, the steeper southern dip is resumed, gradually increasing, until at the bridge it is about 45°. The steep Southern dip continues to the boundary of the limestone and slate, which is seen in the ravine at the bridge, along which the railroad passes. The slate here, dipping to the S., or under the limestone, is evidently inverted by a folding of the limestone, somewhere between this point and the synclinal axis above mentioned. The natural or original position of the great slate formation of the Kittatinny Valley is, of course, *above* the limestone. (See Section of West Bank of the Susquehanna, opposite Harrisburg.)

Boundary of Auroral Limestone and Matinal Slate.—From this point of junction near the bridge, the line dividing the two formations ranges nearly Westward to the most southern bend of the Conedogwinit Creek, following thence the *general* course of that stream, the Southern bends of which reach but do not penetrate the limestone, while its Northern loops lie all within the slate. The limestone, towards its northern margin, contains thin belts of the slate, similar to that noticed as ranging near its Southern side. Near Newville, the boundary leaves the course of the Conedogwinit, to bear somewhat more Southwardly. It here makes a double turn, taking a zigzag course, in consequence of an irregular anticlinal axis near Newville, which elevates the limestone in a long projecting point, penetrating the slate North-eastwardly. Resuming its regular course, it passes S.W. from Newville, leaving Shippensburg three miles to its S.E. ; and then deflecting still more towards the S., it passes a little W. of Green Village, and reaches the Conecocheague north of Chambersburg. It follows this stream past the town, and after pursuing it about four miles, stretches away in a S.S.W. direction to Greencastle, and thence on to the Maryland line, which it intersects about a mile E. of the Conecocheague.

Boundary of Auroral Limestone and Primal Slate.—The Southern margin of the limestone, quitting the Susquehanna two miles below New Cumberland, runs first North-westward, and then Westward for several miles, leaving a narrow belt of the rock on the South side of Yellow Breeches Creek. The overlapping Red Shale crossing the creek about two miles N. of Lisburn, follows its border to Bryson's, west of Lisburn, where the Red Shale leaves the limestone, the formation beyond this point being bounded on the S. by the Primal sandstone. Making the general course of the creek its boundary, the limestone passes by the Southern side of the stream, at Williams's Mill, about three miles N. of Dillsburg, and extends some distance along Dogwood Run, folding round the end of the South Mountain.

Further towards the S.W., the edge of the limestone lies near the North-western base of the mountain, though it is frequently concealed by a covering of diluvium. In some places, owing to a fault or sudden folding together of the Primal slate, immediately at the base of the mountain, the limestone approaches the sandstone ; and indeed in some of the ore banks, situated low down on its declivity, limestone shows itself beneath the ore. In these instances, however, it is probably not the main body of the formation, but a narrow belt in the Primal slates. The limestone, generally, is much interstratified with greenish and reddish slate along the base of the mountain.

Having thus defined, with sufficient accuracy, the two boundaries of this broad tract of the limestone, I shall next give some details connected with the formation.

South-westward from Montalto, much ore strews the surface along the North-western side of the mountain. In the neighbourhood of Tomstown it occurs in large blocks, but is very silicious, being associated with fragments of the yellow silicious rock already alluded to as frequently accompanying the iron ore along the mountain.

The limestone folding round the Southern end of this mountain-ridge extends some distance up the little valley of the Cold Spring Branch, appearing on the North side of Green Ridge below the rolling mill. *Iron ore*, in moderate quantity but of inferior quality, has been dug to some extent on the North-west side of the stream.

A considerable amount of ore is visible in the soil on the farm of Mr Middauer, three miles N.E. from Waynesburg. It is rather too silicious to make a superior iron.

Sulphate of Baryta.—On the Southern part of the same farm, and also on another adjoining one, loose masses of tolerably pure white *sulphate of baryta* occur. It probably occupies a position between the narrow belts of limestone and slaty sandstone which traverse the hills of this neighbourhood.

Proceeding from the foot of the mountain towards Waynesburg, we first meet, after leaving the low grounds, with slaty limestone, alternating for some distance with slate, until we reach the second ridge, three miles S.E. from Waynesburg, where a band of white limestone crosses our section. This latter rock is quarried, and shaped into tomb-stones, about three miles further S.W. On the top of the ridge the limestone is of a dark colour, alternating over a breadth of a mile with bands of slate. In the next ridge, two miles S.E. of Waynesburg, the limestone is interstratified with a thinly-laminated green slate. Near Waynesburg the slate becomes more silicious, some of it being reddish, and nearly all of it containing minute scales of mica.

The line of iron ore seems not to extend South-westward much beyond Middauer's ; for in crossing its range in several places between Waynesburg and the foot of the mountain, few indications of it were visible on the surface.

White Limestone.—On the Southern Branch of Antietam Creek, near the Maryland line, we encounter a band of white limestone at Royer's. The bed is here several feet thick, but somewhat divided by thin sheets of a greenish slate. It is a beautiful rock, of a white aspect and fine texture, and where large blocks are not required, might be advantageously employed as a *marble.*

Cave.—A rather extensive cavern occurs in the limestone at the North-eastern end of a ridge, a little lower down on the same branch of Antietam Creek. Still lower down the stream, at David Funk's, occurs a grey calcareous and silicious rock, in thin layers, from which excellent flagstones are quarried. Again, still further down, and near the State line, there is a belt of limestone, said to yield a lime which will not slack after being burned.

Travertin.—Near the West Branch of Antietam Creek, one mile N.W. of Waynesburg, we meet with a deposit of *travertin,* or *calcareous tufa,* of considerable superficial extent. A similar deposit is visible near the mill E. of Chambersburg, and in several other places along the streams of the limestone region, where the water is highly charged with carbonate of lime. This material, when in a sufficiently pulverulent condition, is an admirable manure, particularly when applied in the form of compost.

Limestone, Fossiliferous.—The North-western border of the great limestone belt passes through the borough of Chambersburg, in the neighbourhood of which some bands of the rock are *fossiliferous*—a character which the formation only rarely assumes anywhere in the Kittatinny Valley north-eastward of Franklin County. These fossiliferous beds belong to the Matinal limestone, or Trenton formation of New York.

About seven miles Southward of Chambersburg, in a ridge called " Grindstone Hill," we find a bed of sandstone interstratified with the limestone, yielding a material suitable for rough grindstones.

Advancing from Waynesburg towards Greencastle, we cross alternating belts of limestone, and interstratified greenish slates ; and beyond these the limestone spreads in a nearly uniform belt, over a considerable breadth of surface, diversified as usual, however, in colour, composition, and qualities. Four miles N.W. of Waynesburg occurs a dark bituminous variety ; and in a ridge two miles further, a band nearly white. Immediately N.W. of Greencastle we encounter the line of contact of this wide belt of the Auroral limestone and the Matinal slates. This latter rock, which we shall next proceed to describe, ranges along the North-western margin of the above zone of limestone the whole distance across the State, from the Delaware River to this point, and Southward into Virginia.

CHAPTER VII.

PRINCIPAL BELT OF THE MATINAL SLATE OF THE KITTATINNY VALLEY BETWEEN THE SUSQUEHANNA AND THE MARYLAND STATE LINE.

Boundary.—The very uniform character and composition of this wide formation, together with its general deficiency in interesting and useful minerals, will render a detailed description of it unnecessary. Its South-eastern margin has been indicated in defining the North-western boundary of the limestone. From the Delaware Water-Gap to Strasburg, in Franklin County, its North-western limit coincides with the base or flank of the Kittatinny or North Mountain, where the formation supports the massive Levant sandstones occupying the summit of the ridge. From Strasburg to the Maryland line, the principal slate-belt recedes from the mountain, and is bounded on the W. by a wedge-shaped tongue of limestone, the boundary between the two rocks passing the villages of Strasburg and St Thomas, or Campbeltown, and intersecting the Maryland line about a mile W. of Conecocheague Creek.

About a mile and a quarter from the base of the mountain, at the Susquehanna River, the slate contains a thin belt of limestone, imperfectly visible at the river-side. Either the same or another bed is seen about a fourth of a mile nearer the mountain. This belt seems to extend Westward several miles, growing, however, gradually thinner and more slaty, and ceasing, probably, S.E. of Sterrett's Gap.

In no part of this belt of the slate formation have the strata the structure and cleavage requisite to produce *roofing-slate.* The nearest approximation to that useful variety yet seen occurs in the bed of the Conedogwinit, above Alter's Mill, where the rock is traversed by cleavage-planes of tolerable regularity, but its usefulness is destroyed by its containing *sulphuret of iron.*

At " Dublin Gap," N. of Newville, there occurs a spring highly charged with sulphureted hydrogen gas.

Some bands of the slate, particularly those lying adjacent to the limestone, are highly carbonaceous, and of a dark colour somewhat resembling the slates of the coal-measures. This analogy in their appearance, notwithstanding the conclusiveness of all geological evidence to the contrary, induces many persons, not familiar with the geology of the country, to suppose that the formation may actually include *coal.* For the last fifty years, excavations have, from time to time, been made at various places in the valley, in the confident belief that coal will be discovered, and though in every instance unsuccessful, they are still occasionally renewed.

This dark carbonaceous slate, the Matinal black slate of our classification, is nowhere a thick formation in the Kittatinny Valley, from many parts of which it is altogether absent. We have already seen that it possesses a very thin outcrop, near Nazareth, and elsewhere in Northampton County. In Centre and Huntingdon counties it is more expanded.

CHAPTER VIII.

BELTS OF AURORAL LIMESTONE AND MATINAL SLATE IN THE SOUTH-WESTERN PART OF FRANKLIN COUNTY.

First Limestone Belt.—The South-western portion of Franklin County contains three moderately broad belts of the Auroral limestone, alternating with three belts of the Matinal slate, occupying the interval between the margin of the great slate belt above described and the Eastern slope of the Cove Mountain. An anticlinal axis ranges nearly centrally along each zone of limestone, imparting to the intervening belts of overlying slate a regular synclinal structure. The relations of these belts to each other are shown in the Section through Bedford to the South Mountain. The most Eastern, and by far the largest range of limestone, is that already alluded to as terminating in a long tongue near Strasburg. It is broadest at the Maryland line, and does not materially diminish in width until we trace it about three miles N. of the Greencastle and Mercersburg road, where it is about three miles wide. West of St Thomas, it is but little more than a mile from its Eastern to its Western border, which is within three-fourths of a mile of Parnell's Knob. Here it curves a little Eastward, taking a direction about N.N.E. to Strasburg, following the foot of the mountain until it disappears in a narrow point under the overlying slate. The anticlinal axis which runs somewhat centrally along this belt, prolonged beyond Roxbury, seems to extend for many miles towards the N.E., being probably the same axis which separates the North Mountain, at Dublin Gap, from the spur lying S. of it, and which is thence prolonged through Perry County.

The usual aspect of this rock is rather uniform. The beds belong to the upper half of the Auroral limestone ; some of those in the Southern part of the tract, near the anticlinal axis, are magnesian.

First Slate Belt.—The belt of slate which bounds this tract of limestone on the W. embracing both sides of Claylick Mountain, at the Maryland line, ranges a little E. of N. to the foot of Parnell's Knob, where it again separates by receiving the mountain in its synclinal axis, one portion passing along the Eastern and the other along the Western base and slope. The overlying Levant sandstone occupying the tops of Claylick and Parnell's mountains, in the middle of this trough of slate, have nearly a perpendicular dip, implying that they have actually been folded together along the synclinal axis, by an action like that of closing a book with its back or cover downwards.

Second Limestone Belt.—West of this belt of slate, the average width of which somewhat exceeds a mile, there ranges a narrow zone of the limestone, traversed longitudinally by an anticlinal axis, which has given to the rocks E. and W. of it the steep inclinations they possess. This anticlinal belt of limestone, passing out of Blair's Valley, between the Claylick and Two-Top Mountains, at the Maryland line, ranges to the mouth of Bear Valley, separating Parnell's from Jordan's Knob. Its average breadth is about half a mile. The rock exhibits the usual variety in its several beds, some of these being silicious, while others again are pure, and adapted to produce an excellent lime by burning. Certain bands of it are evidently of the kind suitable for hydraulic cement. About a mile and three quarters from Parnell's Knob, the soil above this limestone contains a deposit of iron ore, which was at one time smelted in a small furnace at Loudon.

Second Slate Belt.—West of the last-described belt of limestone ranges another parallel zone of the slate, also about half a mile in width, which, like the previously-mentioned slate tract, contains a synclinal trough ; in the middle of this lies the Two-Top Mountain on the S., and Jordan's Knob on the N.

Third Limestone Belt.—To the W. of this slate, there ranges another anticlinal belt of limestone, emerging from between the Two-Top and Little Cove Mountains south of the Maryland line, and passing along the foot of the latter to Loudon, and thence for several miles along the middle of Path Valley, vanish in a narrow point N.W. of Fannettsburg. The elevation of this belt of limestone has caused the Eastern inclination of the rocks in the Two-Top and Jordan's Mountains, and the Western dips in the Little Cove and Tuscarora ridges. We thus perceive that all the valleys subordinate to these axes of elevation contain the limestone or its next superior rock, the slate, having in every case anticlinal dips ; while the mountain-ridges included between these valleys, consisting of the higher Levant rocks, rest invariably in the synclinal troughs embraced between the lines of elevation.

Third Slate Belt.—The narrow belt of slate which overlies the last-mentioned range of limestone occupies the base of Little Cove and Tuscarora mountains, and rises nearly to their summits where it supports the Levant sandstone. Passing W. of Loudon and Fannettsburg by Concord, it extends into North Horse Valley, between the Tuscarora and Conecocheague Mountains in Perry County.

The valley called the Little Cove, bounded by the Cove or Tuscarora Mountain on the W., and the Little Cove Mountain on the E., presents the strata in the form of a synclinal trough, the two enclosing mountains consisting of the Levant sandstone. Both margins of this valley are occupied by the Surgent red slates, seen near the foot of the bounding ridge. The Pre-meridian limestone encircles the Cove, inside of the red shale, and supports in its turn the Meridian sandstone in two belts, the North-western one forming a considerable ridge. The centre of the basin is occupied by the Cadent slates, the strata on the West side of the synclinal axis dipping gently E., while those on the East side are nearly perpendicular. Among the lowest layers of this Cadent slate occurs a highly important bed of iron ore used at Warren Furnace. It is a grey *protocarbonate of iron,* precisely identical in chemical composition with the nodular and plate ores of the shales of the Coal-measures. The discovery of the true nature of this ore, and of the exact place which it occupies in the strata, constitutes one of the most interesting and useful of the developments of a practical kind connected with the Geological Survey. In describing the rocks of Huntingdon and Bedford counties, this important deposit will be again alluded to.

CHAPTER IX.

IRON ORES OF THE KITTATINNY VALLEY.

Postponing to another Division of this Work the discussion of the general geological and chemical relations of the iron ores of the State, and such statistics of quantity and composition as I have to offer, I shall, in accordance with a plan already commenced, present in this place some details respecting the iron ores of the great natural area now described—the Kittatinny Valley. The greater part of these notes, it should be observed, relate to observations made as long ago as 1840, the date of our more minute researches into the geology of the district. Unfortunately time was not allowed me to extend the re-surveys imperatively called for by the progress of development in the coal regions, and some other tracts, to this important zone of country, and therefore some of the statements, especially those relating to the more variable features of the deposits, and to the mere statistics of mining, are partly obsolete; but even these possess a certain permanent value, in showing, if not the exact present condition of things, at least all the real phases which our surface ores assume, under their different localities and different stages of development, by mining. I indulge a hope of being yet able, before the completion of this work, to supplement this account with a description of the chief and most characteristic mines of the surface brown iron-ores, as they now appear. But should this purpose miscarry, enough is here presented to show the distribution, even with local precision, of nearly all the more valuable deposits, and to display the unfailing wealth in iron of this part of the State.

BETWEEN THE LEHIGH AND THE SCHUYLKILL.

Leaving the vicinity of the Delaware River, and approaching the Lehigh near its great bend at Allentown, we find iron ore near the Philadelphia road, two and a half miles S. of that town, in its favourite geological position near the junction of the Auroral limestone and the Primal slate. The deposit seems to be most abundant at the commencement of the steeper slopes of the hills of the Primal formation.

In the low ground S. of the ridge containing the quarries, near the road from Bath to Bethlehem, about one mile from the first-named village, the soil displays indications of iron ore. This spot holds very nearly the position in the limestone belt occupied by the ore-deposit near the Delaware, already spoken of, and by other still more important accumulations W. of the Lehigh. About four miles N.E. of Bethlehem, between Hecktown and Butzville, iron ore of excellent quality was dug upon the farm of Michael Myers, but the quantity obtained at the date of our observations was not great. About five miles, a little W. of N., from Bethlehem, there begins a range of valuable deposits of iron ore, which extend in a W.S.W. direction across the Lehigh, and are prolonged, with some interruptions, for a very great distance.

Previous to our investigations, a shaft was sunk on the farm of Henry Goetz, five miles from Bethlehem, terminating in iron ore at the depth of forty-five feet. To the Westward of this, on the farm of Jacob Rice, much ore has been obtained. The deposit here lies beneath a deep accumulation of common earth. The ore is of variable quality and texture. No limestone had been reached in these excavations, and a well S.E. of the mine reached a depth of ninety feet before it encountered the rock. About 100 yards E. of this mine another was subsequently established. Derby's Mine lies Westward from Rice's one and a half miles. In the same range was Rohn's Mine, affording, like the two last named, chiefly small ore, mixed with much earth, from which it is detached by washing and screening. A few other less important deposits have been met with along this line E. of the Lehigh, and the aspect of the surface is such as to suggest a strong hope that persevering explorations within the belt will issue in the discovery of yet more important accumulations of ore.

Iron ore is abundant on the surface along the Northern base of the hills, South-westward as far as Emaus. About three-quarters of a mile S.W. from this village a mine was opened at Mr Daniel Schwartz's, and subsequently other shafts were sunk a little W. from the old opening. Further S.W. the ore is abundant on the surface, and excavations have revealed it in some quantity. From Emaus towards Millerstown there is also much surface ore, and fine specimens of fibrous hæmatite may be found among it. West of Millerstown there extends a tract of low level land along the North side of the mountain, and the ore is here less abundant. From Millerstown towards Trexlerstown, one mile from the former, much ore was seen on the surface of the fields.

If we now take a position on the Lehigh, 3 miles above Allentown, where the range of the iron ore noticed as occurring at Rice's farm, and other places on the East side of the river, crosses to the West, we find it to be very extensively dug about half a mile W. from Hartman's Dam, near the Furnaces. This deposit lies on the corner of three farms, and is mined on each. The ore lies in the ferruginous clay in the interstices of the limestone rock, and, as might be expected from such a situation, contains much pipe ore, which is evidently of excellent quality. Associated with this are large masses abounding in the red oxide of iron, and apparently of excellent quality. But little hard or compact ore was found here, and much of that formerly obtained by Richards and Smith was prepared by washing the smaller particles from the soil.

This washing is performed at the dam on the Lehigh by a machine. The ore deposit seems to range at first Northward, but gradually to turn to the Westward, forming a kind of semicircular curve. It has been wrought in some places to a depth of about 60 or 70 feet, the limestone rock appearing along the side of the ore.

Rather more than a mile N.W. from this belt of ore, and about four miles N.N.W. from Allentown, successful diggings were made for ore by Major Moyer. The surface-soil is here diluvial matter, with many pebbles of quartz and sandstone, and it exhibits scarcely any signs of ore. The upper surface of the ore was discovered in ploughing the fields, and a shaft was sunk about 30 feet deep. Like most other ferruginous deposits of the limestone region, it consisted of irregular nests and bunches of ore dispersed in loose earth, though the main direction of the ore could be traced dipping Southward. Some of the masses here unburied were of large size. Two principal varieties were met with, large lumps containing much oxide of iron, and between these ferruginous clay, holding a large mixture of true pipe-ore of excellent quality. The surface in this neighbourhood, and S. of it, is chiefly formed of a diluvial deposit, consisting of boulders and pebbles of the compact Levant sandstones of the Blue Mountain, and of white quartz coated with ferruginous matter. This Diluvium or drift probably conceals the outcrop of much iron ore.

Southward from this locality, and about three miles from Allentown, ore was dug at Kratzer's, but the work was not prosecuted to any great extent. This ore lies near the point of a Slate ridge, which extends into the limestone from the Westward, coming in from the main Slate formation near Jordan Creek at Sieger's. The quality is variable, some being compact and hard, while other portions are of more open texture, and better adapted for smelting.

Passing the end of this Slate ridge Northward, we again come upon the limestone, which extends N.W. between this ridge and the main belt of the Slate formation, but which grows narrower, and finally terminates by the closing together of the Slate ridges at a point a little W. of Sieger's Tavern, on Jordan Creek. In this limestone, a little N. of the first-mentioned Slate ridge, on lands of Mr Guth, about five miles from Allentown, iron ore has been dug for some years. It is on the ascending ground a little S. of Jordan Creek.

Immediately S. of these old excavations, shafts were sunk developing a large quantity of a black unctuous clay, said to be 30 feet thick, evidently a decomposed slate, much charged with sulphuret of iron. If rich enough in this material, it may prove of some value for the manufacture of copperas.

Opposite to this place, on the North side of Jordan Creek, iron ore is abundant on the surface, and so continues to the neighbourhood of Sieger's Tavern, near which a mine was in operation, and yielded a considerable quantity of ore. This mine is very near the junction of the limestone and slate; the shaft was about 50 feet deep; and the ore, though said to make a good iron, was too much mixed with slaty and earthy matter to yield a large per-centage. This place is about six miles and a half W.N.W. from Allentown.

Balliot's Mines.—Between two and three miles North-eastward from this point, in the same range, and also near the Northern border of the limestone, are situated the much-noted mines belonging to Stephen Balliot, Esq., where ore has been obtained for many years in large quantity. This ore seems to be chiefly of two kinds: first, the "honey-comb ore," occurring frequently in large masses, a loose open variety, usually found nearest the surface, working freely in the furnace, and said to yield a good iron ; and, secondly, a variety found generally below the honeycomb ore, though sometimes mixed with it, more compact in texture, and containing much oxide of iron. This bank was worked chiefly by uncovering the ore, though several shafts were sunk, and drifts run from them. The deposit appears to be very extensive, the workings already embracing many acres of ground. A little Westward from Balliot's the same body of ore was mined by Richards and Smith.

In one of the North-western shafts at Balliot's diggings, a deposit of the oxide of manganese was found. It was said to be about four feet thick, which probably means that the manganese was scattered through a thickness of four feet of earth and iron ore.

Another shaft, E. of the main workings, exhibited a dark-coloured clay, mixed with small fragments of white quartz. This clay seems to be highly charged with sulphur, but does not contain iron enough to make it a suitable material in an uncombined state for the manufacture of copperas.

This range of iron ore may be traced by surface specimens a mile further Eastward towards the Lehigh, and also occasionally to the S.W. as far as Xander's, where it seems to terminate, the limestone itself ending here by a folding round of the slate hills to the S. of Jordan Creek, near the churches S.W. of Guth's and S. of Sieger's.

Trexlerstown Mines.—The range of ore which has been mentioned as crossing the Lehigh, and passing from three to four miles Northward and North-westward of Allentown, where it has been already noticed at the diggings of Everhart, Miller, Moyer, and Kratzer, may be traced South-westward by the surface specimens in the direction of Trexlerstown. About two miles N.E. from Trexlerstown lies Shoemaker's Old Mine, long unwrought ; and three-fourths of a mile further S.W. occur other openings, on a farm of Mr Grammer. The ore found here was, at the depth at which we saw it, of a rather open and cellular structure.

Near the church at Trexlerstown a mine was opened, exposing a considerable quantity of ore, which was covered with about 20 feet of earth, and was of variable depth, lying in nests and large masses, some of the lumps weighing several hundred pounds. It was in general rather compact and silicious, the limestone here being much mixed with quartz and chert. Several curious varieties of hæmatite occurred in this mine. From this vicinity towards Millerstown, and also South-westward, and Westward towards Breinigsville, the surface indicates the presence of much iron ore.

Near the " Big Spring," a little W. of Trexlerstown, there is a bed of impure black oxide of manganese, appearing in the soil itself near the road-side.

Copperas Mine.—A mile W. of Trexlerstown, and half a mile N.E. from Breinigsville, occurs the noted mine of copperas earth and iron ore, worked, at the period of our first surveys, by Nathan Whiteley. Some borings had been made here by the proprietor, the results of which may serve to illustrate this interesting and singular deposit :—

Result of Borings at the Iron and Copperas Mine near Trexlerstown.

No. 1. West of present Workings. Feet.		No. 2. further Westward. Feet.		No. 3. Eastern Boring. Feet.	
30	Clay and gravel.	15	Gravel and clay.	14	Clay.
4½	Iron ore.	1	Iron ore.	8	Iron ore and clay.
7½	Clay.	15	Clay.	9	Iron ore.
2	Black clay.	5	Slate.	3	Clay.
12	Sulphuret of iron.	6	In clay.	2	Copperas earth.
5	Iron ore.	9	Pipe ore and clay.	2	Do. and black clay.
	Bottom of boring.	4½	Clay.	2	Do. and white clay.
			Bottom.	8	Brown clay and iron ore.
				2	Rock-iron ore.
				8	Clay.
					Bottom.

The black oxide of manganese is found in the upper portion of the iron ore, on the West side of the mine. The silicious slate is somewhat gypseous, evidently from a chemical reaction of sulphate of iron on carbonate of lime in the rock. The origin of this large deposit of sulphuret of iron is to be traced probably to a small shallow bed of Matinal black slate, which appears to have once rested on the limestone, and to have undergone disintegration. The iron ore, or brown peroxide of iron, in contact with the sulphuret of iron, is carefully separated from the rest, and laid in heaps, in order that the oxygen of the atmosphere and the rains may decompose and wash out the sulphurous portion ; but such ore never makes a superior iron.

Westward from Breinigsville the soil presents abundant indications of iron ore, and on a farm belonging, at the date of our visit, to Mr Breinig, about one mile N.W. of the village near the base of a slate ridge, openings were made, which yielded ore in moderate quantities. The ore had generally a rather silicious aspect, and some pieces contained a considerable amount of white quartz.

South of Metztown is Trexler's Furnace. Its ore, at the date of our investigations, was obtained from various places—viz. Moselem, Breinig's, Shoemaker's, the Old Diggings near Kutztown, &c., with some magnetic ore from three miles Southward, at Landis's, and other localities.

About a mile S. of Kutztown, good iron-ore was at one time obtained in some quantity, though subsequently the works were neglected, on account, it is said, of the influx of water. This is in the low ground near the South side of a limestone ridge, which lies between it and Kutztown. The surface-soil between this locality and Kutztown is abundantly strewed with blocks of chert of various colours, but generally dark bluish or black, in masses of considerable size.

On the ridge S. of Kutztown there are extensive quarries of limestone from which much stone is transported into the slate country on the N., and there burned into lime for manure. The dip of the strata at these quarries is about 20° S. A white clay is also found at the iron mine. The *Moselem Iron Mines* lie near the Northern border of the limestone within about 900 feet of the foot of the slate hills, five miles W.S.W. of Kutztown, corresponding in geological position with Balliot's Mines in Lehigh County. The ore is obtained by sinking shafts through the soil, and is commonly reached at a depth of from 20 to 40 feet. The diggings are very extensive, covering an area of several acres, and have been wrought for very many years, yielding a large amount of ore. This is said to occur in nests and irregular layers, varying in thickness from 1 to 8 feet; it is of good quality. Some of it has a bluish tint, and contains a little manganese. On the top of the ridge S. of these mines the limestone is visible with a very gentle *Northern* dip. Large quantities of a dark-coloured chert are scattered over the surface, some of the masses weighing several hundredweight.

Iron ore is indicated on the surface near the two-mile stone on the turnpike N. of Reading.

About one mile N. of this town there is a narrow insulated belt of Primal Slate, constituting a ridge which runs Westward, and half a mile N. of the town there occurs another narrow outcrop of the Primal sandstone, barely visible in the Southern slope of the hill.

Between the Schuylkill and the Susquehanna.—The few notes relating to the less important localities of Hæmatitic ore within the Kittatinny Valley, between the Schuylkill and at Susquehanna, have been already given in Chapter V., describing the geology of that tract, and the reader is referred to the general Chapters on the Ores of the State for an account of the only one great ore mass of the district—that of the great Cornwall mine.

BETWEEN THE SUSQUEHANNA RIVER AND THE MARYLAND STATE-LINE.

Proceeding Westward from the Susquehanna, we meet with a large deposit of good iron-ore, about two and a half miles from the Harrisburg Bridge, called the Gorgas Ore Bank. The ore is imbedded in the ferruginous soil which overlies the limestone. It occurs in bunches and irregular veins, the general course and dip of which coincide somewhat with those of the underlying rock. It is extensively mined, and is conveyed by railroad and canal to the smelting furnaces along the Susquehanna, especially to those of Governor Porter at Harrisburg, and under skilful treatment produces an excellent metal.

A trap-dyke crosses the Yellow Breeches Creek about two miles N. of Lisburn, altering more or less the adjacent limestone. In the vicinity of Sheperdstown, three miles S. of Mechanicsburg, the limestone encloses a considerable tract of slate, rather more than half a mile in breadth. This is probably a belt of Matinal Slate folded in between the limestone in a compressed synclinal axis. About a fourth of a mile N.W. of Sheperdstown, iron ore, apparently of good quality, has been obtained. It has not proved abundant, though little has been done towards developing it.

At the Carlisle Iron Works, six miles S.S.E. from Carlisle, a trap-dyke, traceable from the mountain, crosses the Yellow Breeches Creek immediately at the furnace, and extends N. 20° E. entirely across the valley, meeting the base of the Kittatinny or North Mountain, about two miles E. of Sterrett's Gap. It forms a sharp, very narrow, rocky ridge, from 10 to 17 feet high—a useful natural boundary employed to designate the Township lines. The limestone is considerably affected by it in its texture and colour, though not much disturbed in its prevailing South-eastern dip. In a quarry near the furnace, a little removed from the trap, the rock has the aspect of fine-grained, whitish, and dove-coloured marble. This trap-dyke, and the contiguous beds of the limestone, are well seen in the cutting on the Harrisburg and Chambersburg railroad, where the dyke is about 60 feet wide. Another lesser trap-dyke penetrates the limestone a little Westward of the former.

The iron ore which supplies the Carlisle Iron Works is obtained at several points. The variety denominated "mountain ore," occurs along the Northern slope or base of the first sandstone ridges, near the junction of the limestone. Another variety, known as limestone or *pipe ore*, belongs to the ferruginous soils overlying the limestone itself. The iron obtained from the mountain ore is generally "cold-short," hard and brittle; while that derived from the limestone ore is softer, tougher, and more tenacious. The mountain ore is in some furnaces employed alone for the manufacture of foundry pigs and castings, but a mixture of the two kinds is generally deemed necessary for the production of good cast-iron for forging or puddling. One principal reason of this is, that in the mountain ore, derived originally from the Primal strata, the oxide of iron is associated with a larger proportion of the oxide of manganese, and other deleterious constituents, than generally accompany it in the ores originating from the limestone. Both of these varieties belong to the general species, called by mineralogists brown hydrated oxide of iron, though they assume a considerable diversity of aspect and structure, arising from their greater or less degrees of richness and purity, and the manner of their concretion.

The "mountain ore" obtained a mile and a half South-west of the Carlisle Works is of several descriptions. In the upper portion of the deposit, much of it is compact, passing under the name of "hard ore." The "honey-comb ore," lying beneath this, or imbedded between it, is a softer and more porous variety, more readily reduced in the furnace. Half a mile S. from the furnace, a small body of a somewhat different ore has been met with.

The "limestone ore" employed at this furnace was obtained from a belt about two miles N.N.W. from the works, where ore had been dug, in different places, for several years. The supply in 1840 was chiefly from a deposit about eight feet thick. Much of it belongs to the fine variety denominated "pipe ore," consisting of a congeries of parallel stalactitic tubes or stems, from whence it derives its name. One part of this ore is mixed with two parts of mountain ore in the manufacture of forge pigs. For the chemical composition of these several varieties, see the general Chapter on the Iron Ores.

Between the deposits of limestone ore above-mentioned and Carlisle, ore has been found in several places; an extensive digging, now abandoned, occurring near the Hanover road. Half a mile S. of this, on a farm belonging to Mr Holmes, a very good-looking ore was found, and subsequently mined. Between this spot and Carlisle, other excavations exist, from whence the ore was conveyed across the North Mountain to a furnace S. of Landisburg, where it was mixed with ores of that neighbourhood.

In the neighbourhood of Carlisle there occurs much good limestone; both the ordinary kind, adapted for making lime, and the magnesian variety, suitable for the manufacture of *hydraulic cement*.

About four miles Westward from Carlisle, near the State road, there occurs a neglected excavation where iron ore to some extent has been procured. About four and a half miles S. of the town, near the turnpike, there is a deposit of apparently good ore, formerly wrought to some extent, to supply Holly Furnace, not now in operation. On the Walnut Bottom road, about five miles S.W. from Carlisle, ore is abundant on the surface of a little hill. Southward of this, at Peffer's, between the foot of the mountain and the creek, ore was formerly obtained for Holly Furnace, and more recently for Cumberland Furnace. Though not far from the sandstone of the mountain, some of it is of the variety called pipe ore; parts of it, however, are manganesian. Along the low ground, near the foot of the mountain, ore is abundant on the surface for a considerable distance Westward.

Cumberland Furnace has been smelting chiefly the ore obtained near the base of the sandstone ridge of the mountain about three miles S.W. from the furnace. This ore appears to lie in bands, and large bunches or nests in the loose soil near the bottom of the declivity of the mountain. The mine generally wrought is an irregular excavation, from forty to fifty feet deep, in the sides of which the ore is scattered in lumps throughout a large extent of the deposit, but is best and most abundant nearest the bottom. The ore from this bank is mixed with another ore from the limestone tract obtained a mile and a half north of the furnace. For an analysis of each of these ores, see the general Chapter on the Iron Ores.

Iron ore occurs on the surface about seven miles west of Carlisle, on the farm of Mr William Kerr, in considerable quantity.

Near the Big Pond at the head of Yellow Breeches Creek is Pond Furnace. The ore smelted at this furnace is procured from the Primal slate, on a low spur of the mountain, S.W. of the Pond. The old excavations on the Eastern side of the hill have been abandoned, and another deposit opened on the Western side. The limestone employed as a flux in Pond Furnace is collected from the surface fragments of the neighbourhood, and is therefore of every diversity of character.

Mary Ann Furnace lies about three miles West of the Pond; near it is Augusta Furnace. These furnaces are situated close to the foot of the mountain, about three miles S.E. of Shippensburg. Mary Ann Furnace is supplied with ore from two banks, opened many years ago, one called the "Helm Bank," three miles N.E. of the furnace, and another called the "Clippinger Bank," two miles towards the N.W. The Helm Bank ore overlies that part of the limestone which is much interstratified with slate, being near its margin. The ore dips steeply to the N.E., but varies much in quantity in different parts of the excavation. The Clippinger Bank yields an ore of the very best description, much of it being stalactitic, or of the kind called pipe ore. The analyses will display the prevailing composition of the ores of both these banks.

The Clippinger ore occurs in regular nests in the interstices of the limestone rock, surrounded by a very tenacious reddish clay. The quantity fluctuates much in different spots, and the water incommodes more or less the deeper diggings. These circumstances attend nearly all the deposits of the limestone ore in the valley. Where the ore occupies the interstices between the beds of limestone, it is almost invariably pure and of the pipe-ore kind, though the quantity in these situations is apt to be precarious. The mountain ore obtained near the junction of the Auroral limestone and the Primal slate of the mountain is procured with greater certainty, but is frequently quite unfit for making forge iron, without an admixture of the pure ore of the limestone, being used by itself only for foundry metal. The flux used in Mary Ann Furnace is a limestone procured in the vicinity of the Clippinger Bank.

Southampton Furnace is situated about three miles further to the S.W., or four miles S. of Shippensburg. These two furnaces when in blast were supplied with ore from three different banks. One called the "Hill Bank," lying about three hundred yards W. of the upper furnace, contains the mountain ore in its usual varieties. That in the upper part of the mine is cold-short, while a honey-comb ore lying beneath it is of much better quality. The ore of this bank supplied the upper furnace which used the hot blast, and made foundry iron and castings.

The lower furnace was furnished with ore from a mine at Kressler's, three-fourths of a mile to the N.W., and also from the "Railroad Bank," lying in the limestone formation, four miles W. of the furnace. The ore at Kressler's has been extensively wrought for many years. It occurs in nests and irregular layers in the soil and the rotten slate, the deposit having a dip nearly coinciding with the direction of the underlying strata. This ore is esteemed to be well adapted for making good bar-iron, but is less productive in iron than some others in the neighbourhood. Much loose ore is visible on the surface, N. of the present excavation. The "Railroad Bank" formerly yielded a valuable supply of good ore, but the encroachment of the water, and a reduction in the quantity of ore, subsequently caused it to be less actively wrought. The ore exists rather in bunches or nests than in regular layers, and is hence very variable as to quantity. A small ridge of limestone bounds the ore immediately on the N. The lower furnace, smelting these ores, made forge pigs for bar-iron. The composition of these ores will be found in the Tables of Analyses.

Proceeding Northward to the neighbourhood of Shippensburg, it appeared that a moderate amount of excellent ore had been procured in a spot called the "Pilgrim Bauk," near the Northern margin of the limestone, three miles and a half from the town. A good ore was formerly obtained on the farm of Mr Hamills, a mile and a half S.E. from the town. Ore was also procured about a mile and a half W. of Shippensburg, at the old Roxbury bank. It was the *stalactitic* or *pipe ore*, and made a bar-iron which was much esteemed for its soft and tough qualities, but, as usual with ore of this description, the quantity was limited. For analyses, see the Tables.

About two miles S.E. from Green Village, and half a mile N. of the railroad, a deposit of beautiful *pipe ore* of excellent quality was wrought for the supply of Caledonia Furnace, to which it was conveyed a distance of eight miles in waggons. It produced a good iron, and with great facility, agreeing in these respects with the pipe ore generally. It occurs in bunches, which together form an irregular layer, conforming with the direction of the adjacent limestone. Its position is between two little ridges of the limestone, one of which immediately bounds it on the N. It is deeply covered with earth, and is somewhat expensive to procure.

Caledonia Furnace is situated on the Gettysburg and Chambersburg turnpike, ten miles from the latter place. It is supplied with ore from several deposits, besides the Green Village bank already noticed. A belt of ore-ground extends for apparently several miles nearly along the line of contact of the limestone of the valley and the sandstone of the ridges, which jut forward in advance of the main body of the mountain. On this line of ore, coinciding with the position of the Primal slates, which intervene between the limestone and the sandstone, the Pond Iron banks occur about three miles from Caledonia Works. They consist of extensive diggings, in which the ore is met with at various depths, in nests and irregular layers, in a ferruginous soil. Much of this ore has a hollow reniform structure. About three hundred yards S. of this spot, a bed of ore was formerly wrought for the supply of Montalto Furnace. It overlies the sandstone, and yields a metal of very indifferent quality. The flux employed in Caledonia Furnace is procured a little N. of the Pond diggings.

Another excavation furnishing ore for the same furnace occurs three miles further to the S.W., at Hiefner's. This bank, situated further from the mountain than the former, yields an open and crumbly ore, which smelts with facility, but produces a somewhat cold short iron. The chemical composition of these ores will be found among the analyses in the Tables.

In one of the openings at Hiefner's, an impure limestone was encountered thirty feet from the surface. A little Eastward of the openings some pipe ore occurs in the soil, for an analysis of which, see the Tables.

Another belt of ore-ground seems to exist on the summit of a little ridge of limestone N. of the former excavations. This ore is different in quality from the other, and promised to be abundant twenty feet below the surface. The ridge extending South-westward, the ore seems to continue along it, and about three-fourths of a mile from the Hiefner bank occupied the surface in an abundance seldom seen. It had been partially opened here, but making a highly cold-short iron, was abandoned. These deposits of ore seem to range nearly along the line of contact of the limestone, and a narrow interposed belt of silicious slate and sandstone.

About a fourth of a mile S.E. of Beattie's, on the turnpike, occurs a dark-coloured limestone, an unsuccessful trial of which as a flux was made in the furnace. The analyses, showing its composition, will be seen in the Tables.

Iron ore of very inferior quality occurs between two ridges of sandstone, three miles N.N.E. of Caledonia Furnace, affording another evidence of the impure nature of the ores derived from the rocks of the South Mountain, when compared with those which occur in the limestone of the belt immediately N.W. of it.

Montalto Furnace is situated on a branch of Antietam Creek, about seven miles N.E. from Waynesburg, and near the foot of the outer sandstone-ridge of the mountain. Though iron ore appears upon the surface, in more or less abundance, the whole way along the North-Western base of the mountain from Ege's Carlisle Works to this place, yet nowhere does it occur in such profusion as between the Caledonia Ore Bank at the Pond, and a point two or three miles S.W. of Montalto. This furnace was supplied from extensive excavations lying about a fourth of a mile N.E. of it, on the declivity of the first sandstone-ridge. The ore occurs, as in other similarly-situated mines, in the loose soil of the mountain-side, in nests and irregular layers, varying greatly in their dimensions ; but the whole deposit seemed to be of prodigious magnitude. The lower portion of the ore was the purest. This ore, though abundant in quantity, does not, however, yield a large proportion of iron. The composition of these two ores is recorded in the Tables.

In one of the deeper diggings of Montalto, a band of limestone was reached, being probably a layer in the Primal slates. It is interesting thus to observe the prevailing connection between the limestone and large deposits of iron ore.

On the West side of the most Western tract of limestone, in Franklin County, about four miles W. of Loudon, a deposit of iron ore occurs, formerly smelted in the old Mount Pleasant Furnace near it, but now taken to Carrick Furnace, four miles towards the N. The ore ranges, in greater or less abundance, for six or eight miles, in a narrow line along the S.E. base of the Tuscarora Mountain, being procured in considerable quantity N. of Carrick Furnace. Its position is near the contact of the limestone and overlying slate. It is of two varieties : one a hard ore, occasionally iridescent, making a rather cold-short iron ; the other a "honey-comb ore," esteemed to be of much better quality. The analyses, showing their chemical nature, may be found in the Tables.

The limestone employed as the flux in Carrick Furnace is procured in part from a quarry adjacent to the works, and in part from the loose pieces scattered through the neighbouring fields. A little *pipe ore* has been occasionally found.

About five miles N.E. of Mercersburg, and two and a half miles from St Thomas, not far from the anticlinal axis, lies a deposit of iron ore, no longer wrought. It is stated to have yielded a good, soft iron ; it was, however, red short, or brittle, at a welding heat. When roasted or smelted, it gave off a strong odour of *garlic*,—a circumstance indicative of its containing *arsenic*. The presence of arsenic in this ore I have ascertained by analysis, the results of which may be seen in the Table showing the Composition of the Iron Ores.

BOOK III.

DISTRICT OF THE ORWIGSBURG AND STROUDSBURG VALLEY.

CHAPTER I.

LIMITS OF THE DISTRICT, AND CHARACTER OF THE FORMATIONS.

THE division of the State which is now to be described may be regarded as a single valley, enclosed between the Shawangunk, Blue, or Kittatinny Mountain on one side, and the Catskill, Rocky, Pokono, Mahoning, or Second Mountain (for by all these names it is known) upon the other. Twelve or fifteen miles broad, where it enters the State from New York at Carpenter's Point, this valley becomes scarcely two miles wide at its intersection with the Susquehanna, six miles above Harrisburg. The alterations of form where it expands and contracts in width, are sudden but regular, and due in every instance to the appearance and disappearance of numerous anticlinal flexures, some of which arise within it, while others enter it from the great Kittatinny Valley. These latter crossing obliquely through the Kittatinny Mountain, form synclinal knobs or spurs on the Southern side, and anticlinal knobs or promontories on the Northern side of that high ridge—the one class projecting Eastward into the Kittatinny Valley, the other advancing Westward into the Stroudsburg Valley. These closely-folded flexures occur at intervals along the whole course of the Kittatinny Mountain, and confer upon its generally monotonous crest almost its only features of diversity. By a reference to the Map, one of these anticlinal spurs may be observed at Milford, another at the Walpack Bend, a third at the Delaware Water-Gap, another at the Wind-Gap, and a group of four or five together at the Little Schuylkill. One law regulates their occurrence in all cases. The anticlinal axis or flexure, approaching the mountain Westward from the Kittatinny limestone valley, where it is in maximum force, ascends through a long, narrow cove of Matinal slates, then passes through the mountain as an arch, in the Levant grey and white sandstones, and issues on the other side in the form of a long, pointed, gently-declining spur of Surgent slates and shales, around and over the end of which, curve and arch successively the Pre-meridian, Meridian, Post-meridian, and Cadent rocks.

After passing through the mountain in this very oblique manner, each anticlinal axis continues its Westward course, nearly parallel with the medial line of the valley for several miles, and many of them pass out from the valley through the next mountain-ridge bounding it on the N., in a similar manner, forming analogous knobs and curves in the mountain on that side.

Thus the Milford axis forms the cove behind the Pokono Knob, N.W. of Stroudsburg; the Walpack Bend axis is another that may be looked upon in its prolongation Westward, as that of the Cove behind the Kettle Mountain east of Mauch Chunk; and an axis originating where the Water-Gap anticlinal dies away, after traversing the valley for forty miles, passes out of it through the curve of the Wildcat or Mahoning Mountain, deflects the Sharp Mountain, and enters the Pottsville Coal-basin at Middleport; and the final contraction of the valley at Pinegrove is due to an almost similar entrance of another anticlinal flexure from the E. near the Little Schuylkill.

At every point, therefore, along its whole extent, a section across this belt exhibits the presence of one or more important flexures. Such a section also displays, on the Southern side, the older rocks, the Levant sandstones, slates and shales, forming the Kittatinny Mountain, and dipping steeply Northwards; in the middle, the Cadent and Vergent rocks; and on the Northern side, the almost horizontal Ponent and Vespertine series, cropping out along the grand escarpment of the great Catskill or Pokono Mountain plateau, or in the country W. of the Lehigh: these latter rocks nearly vertical, and forming the double-crested summit of the Mahoning or Second Mountain.

The Meridian series, which occurs along the Shawangunk Mountain in New Jersey, cannot be traced continuously to the Westward beyond the Lehigh. The Pre-meridian limestone series forms also a thin and waning outcrop, and finally ceases within this belt W. of the Swatara. The sections across this zone at the Delaware and Lehigh, and at the Susquehanna, will amply explain the conditions in which the several strata occur in its Eastern, Middle, and Western divisions.

CHARACTER OF THE STRATA IN THE DISTRICT.

Though narrow, the Third District embraces a considerable number of formations—namely, those of the Levant, Surgent, Pre-meridian, Meridian, Post-meridian, Cadent, Vergent, and Ponent series. These are best developed in the region of the Delaware, for some of the strata thin out towards the S.W. The sections at the Delaware, Lehigh, and Susquehanna will give a clear idea of the composition and dimensions of the several groups in the types which they there exhibit. With the aid of these diagrams a very brief account of the rocks will suffice to present a perfect key to the geology of this district. (See Sections of Delaware, Lehigh, and Susquehanna Gaps, in the Kittatinny Mountain.)

DESCRIPTION OF THE STRATA FROM THE DELAWARE WATER-GAP NORTHWARD TO BROADHEAD'S CREEK.

The Levant rocks on the New Jersey side, in the Kittatinny Mountain, show a strike N. 70° E., with dip 35° or 40° to N. 20° W. On the Pennsylvania side, the strike is N. 60° E., the dip about 35° to N. 30° W.

1. *Levant Rocks, Kittatinny Mountain.*—The lower main rib consists of grey conglomerate and sandstone; the conglomerate is most abundant towards the base, and is composed of quartz pebbles of nut and pea size, with scattered pebbles of black slate, some of them one and a half inches long. This is evidently the equivalent of the coarse conglomerate of the Lehigh Gap; but here the pebbles are smaller, and a large proportion of the mass is sandstone. Thin partings of black fissile slate, two to four inches thick, occur in it. Light grey sandstone constitutes the upper portion of the stratum. The whole thickness of this member is about 300 feet.

2. The second member is a soft sandy rock, including a thin rib of hard material. The chief part of this mass

consists of thin-bedded dark grey sandstones, inclining to olive. Many of the layers contain scattered quartz pebbles. Thickness about 400 feet.

3. The third member forms a prominent thick rib of the mountain, and consists of light grey and olive grey, very compact sandstone, some of it pebbly, and occasionally between the beds are partings of grey flaggy sandstone. It has a thickness of about 200 feet.

4. *Surgent Strata.*—The fourth group consists of dark-greenish grey, and brownish and light-grey sandstones, with hard semi-vitreous, reddish sandstones, occurring near the middle of the mass, the light-grey being near the top. The whole mass passes upwards into a hard, arenaceous reddish shale and shaly sandstone. The entire thickness of this member is about 400 feet.

This group appears to begin the Surgent series, its upper grey sandstone representing perhaps the Surgent iron sandstone; this is indicated by a comparison of the section with that at the Lehigh Water-Gap, where there is a similar absence of the lower Surgent slates.

5. The next division is a deep red argillaceous sandstone or highly indurated sandy shale, including thick bands of an olive-green argillaceous sandstone and shale; the more sandy beds are often quite pebbly. There are layers of light-greenish-grey flaggy sandstone, but the red sandy shale greatly predominates. Towards the top of the mass the greenish shale becomes intercalated with red shale. The thickness of the whole is about 350 feet.

6. A mass of indurated sandy shales succeeds, composed of red, olive, and greenish-grey beds alternating, the red being confined to the lower half. This portion of the series lies in several broad flat undulations, upon one of which is perched the Water-Gap Hotel, in a position commanding a fine view of the pass and valley. All this portion of the formation displays cleavage-structure very conspicuously, dipping invariably to the S.E., but at all inclinations, from steeper than 60° nearly to horizontality; the flattest dip being always on the North-western side of the anticlinal curve.

In this vicinity—namely, to the N.W. of the Hotel—the strata exhibit a curve in their strike which sweeps more South-westward than the mountain-crests, or the great anticlinal lines of the country. This bending round of the rocks is due to the sinking South-westward of an important anticlinal flexure, which, coming out from the Kittatinny Mountain east of the Delaware River, here subsides not far W. of the road leading from the Gap to Dutotsville. The anticlinal shows itself in the form of the hill on the Jersey side, and is the principal flexure N. of the Gap. Eastward it swells into a mountain-ridge, vying in elevation with the main monoclinal crest of the Kittatinny.

7. North-west of the variegated group above described succeeds the true red shale member of the Surgent series plainly exposed on the hill to the W. of the village of Dutotsville. It dips 25° to 30° N.W., composing the hill to its base, where the diluvium of the valley commences and conceals for a space all the overlying formations of the Surgent series. This red shale exhibits distinct cleavage-planes, dipping as usual to the S.E. The thickness of the red shale is apparently 200 or 300 feet, but in this vicinity it is not susceptible of accurate estimation.

Prolonging our section, we cross the broad Diluvial flats of the valley to the base of the limestone and sandstone ridge called Fox Hill, a blank space of about 2000 feet measured across the strike of the strata of the district. It is impossible to say whether the prevailing N.W. dip continues under the whole of this interval, or whether there enters one or more gentle flexures; but the smoothness of the valley implies the absence of any considerable undulation, and this is further indicated by what we know of the structure of the country N.E. and S.W. of these flats. Assuming the dip to be all in one direction and to average 20°, the thickness of the strata covered up will be about 700 feet. The portion adjoining the red shale must be the Surgent variegated shales, the highest division of the series, and probably these fill the entire interval, since we have no evidence of the existence in this region of any strata of the Scalent series—the Niagara group of New York and the Western States—which intervene between the Surgent shales and the Pre-meridian limestone, the first rock here met with on the North-western margin of these flats.

Pre-meridian Limestone Series.—Along the base of Fox Hill, but best seen for measurement a little S. of the bridge across Broadhead's Creek, we detect these rocks, and thence crossing the ridge or following the line of natural exposure in the back of that stream, we are able to extend our section from near the base of the Pre-meridian limestone to the Cadent rocks, and even far beyond. Enumerating the formations we encounter—

I. A little S. of the bridge, nearly horizontal surfaces of Pre-meridian limestone full of *Pentamerus galeatus.* This is for the most part a thinly-bedded argillaceous limestone with limestone shale; thickness about 60 feet.

2. Next succeeds a shaly limestone, the Pre-meridian shales, abounding in *Delthyris macropleura.* Its thickness is some 30 feet.

3. Next follows a calcareous sandstone somewhat pebbly, 15 feet in thickness. This is not the Meridian sandstone, but a member of the Pre-meridian limestone.

4. *Meridian Sandstone Series.*—Upon the sandstone reposes an impure limestone, or rather a calcareous shale, containing layers of chert. This rock has a thickness of 50 feet. It is apparently an upper member of the Pre-meridian limestone, but more properly it belongs to the Meridian series, and is the equivalent of the Meridian dusky shale of other localities.

5. Resting on this calcareous rock is an ash-coloured shale—embracing beds of chert and several calcareous bands—30 feet thick in its upper portion. This group is about 80 feet thick in all.

This stratum is to be regarded as the second member of the Meridian shales frequently seen in this position on the upper Juniata.

6. The next which succeeds is an arenaceous limestone, with courses of blue chert predominating in the lower layers, the upper portion being in part a coarse and pebbly sandstone. This is about 30 feet thick, here wearing the usual attenuated condition it has along this first South-eastward outcrop N.W. of the Kittatinny Mountain.

Though destitute in this locality of fossils, it bears all the indications of being the Meridian sandstone, or F. VII. of the Annual Reports, the Oriskany sandstone of the New York Geological Survey.

7. *Post-Meridian Series.*—Following the sandstone is a sandy shale, containing many impressions of the peculiar fucoid called the *Cauda galli*, from its resemblance to a cock's tail. This rock by estimation is from 120 to 150 feet thick.

The last formation is much intersected by planes of cleavage, which dip with great regularity rather steeply to the S.E.

Cleavage near the Delaware Water-Gap.—At the Kittatinny House, N. of the Water-Gap, the Surgent variegated marls and indurated shales exhibit cleavage very distinctly; its dip is a little W. of S., which appears to be its prevailing direction in all this district N. of the Gap. At the Kittatinny House the strata dip S. 40° W.

The cleavage pervades all the more argillaceous beds in planes extremely close together, while in the more arenaceous rocks, alternating with the shales, the fissures are usually some inches asunder.

It is an interesting fact that, not only here but throughout the districts of cleavage generally, this feature abounds much more on the Northern dips than on the Southern; or, in other words, it predominates on the most incurved sides of the anticlinal and synclinal flexures. It appears to me that this fact is of itself conclusive against the hypothesis which ascribes the cleavage-structure to a lateral mechanical compression, for it is obvious that, at the formation of the undulations in the strata, there must have been as much stretching or dilatation at the convex curves as squeezing or compression at the concave.

DESCRIPTION OF THE STRATA FROM THE LEHIGH GAP NORTHWARD.

The following is a description of the strata as they are exposed in the Lehigh Water-Gap or pass of the River Lehigh, in the Kittatinny Mountain.

Observing the ascending order, the first formation met with in the Lehigh Gap is the Matinal slate. Starting from the top of this we have, composing the

LEVANT SERIES,

1. An egg conglomerate of grey-sandstone paste holding pebbles of quartz, Matinal chert and slate, and Primal slate and sandstone. Thickness, 50 feet.

2. An alternation of fine-grained white and pinkish sandstone and nut conglomerate, containing pebbles of quartz, slate, and chert in a grey paste. This is capped by about 10 feet of egg conglomerate similar to that above described. The whole stratum has a thickness of 75 feet.

3. Nut conglomerate, pebbles consisting chiefly of quartz, which in some beds repose on quartzose sand. Thickness, 75 feet.

4. Fine-grained white and grey sandstone 10 feet thick, followed by an alternation of grey sandstone and pea con-

glomerate, the sandstone mingled with argillaceous matter, predominating in the higher beds, and not so thickly bedded as the conglomerate strata beneath. Whole thickness, 200 feet.

This brings us to the synclinal trough, whence to the anticlinal roll N. of it is 225 feet horizontally. After passing these flexures, we have a wide space of 450 feet horizontally of apparently soft rocks, presenting no good exposures except near the middle where there occurs a thick bed of sandstone.

5. Whitish and grey sandstone containing pebbles, the partings argillaceous. Thickness, 80 feet.

6. Greyish-white sandstone alternating with indurated brownish sandy shales, not well exposed. Thickness about 100 feet.

7. Whitish sandstone having argillaceous partings overlaid by brownish and greenish slates, exhibiting vague fucoidal markings or blotches. 50 feet thick.

8. Indurated sandy shales tinged brown, olive, and yellow, vaguely marked by fucoids. 30 feet thick.

9. Indurated shales, brown, olive, and buff green, interstratified with beds of grey and greenish flaggy sandstone; about 200 feet thick. This brings us to the Lehigh-Gap Hotel.

10. Indurated olive and yellowish shales, and massive, ponderous, red-and-grey quartzose sandstone; the partings are thin bands of shale marked by reticulated fucoids. Over these is a thick mass of ponderous grey quartzose sandstone. Thickness of the group, 100 feet.

SURGENT SERIES.

Aquanchicola Creek, which meets the Lehigh, conceals about 100 feet of these strata.

11. Indurated red and greenish shales. Near the base of these is a band, five feet thick, of iron sandstone overlaid by alternating bands of olive and red ferruginous indurated shales full of fucoidal markings of the Surgent newer slates and iron sandstone. Thickness of this group, about 170 feet.

12. A grey and rather vitreous sandstone, somewhat thin-bedded, with partings of slaty sandstone 100 feet thick. This appears to be the equivalent of the Ore Sandstone of the Juniata country.

13. A thin-bedded greenish-grey sandstone, with olive and buff-coloured argillaceous and sandy slates, the argillaceous slates predominating in the higher portion, where also reddish sandstones and shales begin to appear. Thickness, 120 feet.

14. Red shale and red sandstone of the prevailing type of the Surgent red shale.

Section on the Lehigh from South Side of Stone Ridge Northward.—Proceeding Northward from the Southern base of Stone Ridge through a good series of exposures, the lowest group of the strata developed belongs to the higher part of the Scalent series. From the termination of the Section of the Lehigh Water-Gap which ends about the upper limit of the Surgent red shale, to the beginning of these exposures of variegated shales, is a space across the strike of about 2250 feet, with an average dip of 45°, all of which would appear to be occupied by the Scalent variegated and grey shales.

At the base of Stone Ridge we meet a thin development of the Scalent limestone, somewhat argillaceous and full of *Beyrichia* and other characteristic fossils.

Succeeding the limestone is a belt of variegated shales apparently of the Scalent age.

A bed of chert follows these, apparently the sole representative of the Pre-meridian limestone series. Upon it is a thin stratum of dusky shale, and over this about 175 feet of pebbly sandstone, then 30 feet of shale, and again 25 feet of sandstone surmounted by a thin layer of chert, all these four rocks constituting the Meridian series.

Upon the last sandstone rests a dark slate, seemingly the black slate at the base of the Cadent series.

From the deficiency of exposures, the section skips an interval of more than 3000 feet from the North base of Stone Ridge to a point further Northward.

The first exposures consist of the upper members of the Cadent shale formation under the form of olive shales and black slates. They dip at an angle of about 40° Northward, and are somewhat intersected by cleavage planes-dipping at the same angle South-eastward.

These are succeeded by the *Cadent upper black slates* in their usual form of fissile black slates, easily distinguishable from the more shaly members below. The thickness of this formation here, on the Lehigh, is about 250 feet.

The *Vergent series* is well exposed, overlying the Cadent slates. It presents itself as made up of alternating bands of grey sandstone and olive shale of the Chemung type. The dips are fluctuating throughout the mass; at its contact with the slates beneath, the inclination does not exceed 40° towards the N., but it soon steepens into 70°, and then declines again into 45°, after which the strata undergo several small undulations, and finally are lifted upon an anticlinal arch, the opposing dips of which are 25° Southward, and 70° Northward. Passing this arch, the grey rocks of the formation become more prominent, but are soon seen in alternation with the lower members of the next overlying series, or Ponent rocks, throughout a flatly undulated tract just S. of the mouth of Pogopogo Creek. The total thickness of the Vergent series as thus exposed is from 1700 to 1800 feet.

At Pogopogo Creek the dip is gently Northward, but it soon turns, and 300 feet above the creek the upper grey bed of the alternating rocks is seen spanning a low arch.

From this anticlinal it is only 500 feet to the main central synclinal axis of the valley. This axis forms a prominent ridge occupied entirely by rocks of the *Ponent series*, which dip 15° N. on the South side of the basin, and 20° Southward on the North side, flattening gradually down to 10° as we recede from the axis. The centre of the basin only is occupied by true homogeneous red shale; passing Northward, these soon alternate with olive shales, and then with the sandstones of the Vergent, as we have seen was the case on the South side of the synclinal axis. In the Ponent rocks, cleavage is a somewhat conspicuous feature. It dips uniformly Southward at the high angle of 70°.

The alternating measures cease about a 1000 feet N. of the axis, and we enter upon Vergent rocks. These exhibit themselves in a long series of exposures on the Lehigh. They consist for the first three-fourths of a mile of flaggy, greenish-grey sandstones, alternating with thin layers of argillaceous sandstone, and olive and blue clay-slate; the shaly beds augmenting in thickness and proportion towards the top of the formation. Fossils are few, but those to be seen are chiefly vegetable, as stems of ferns. *Fucoides velum*, and a few *Nuculæ*, are also found. The flaggy beds exhibit well-preserved ripple and shore marks, and trails of marine creatures, &c. The dip is somewhat fluctuating though quite gentle; it does not exceed 20°, and is frequently as low as 15° Southward.

From Lock No. 10 of the Lehigh Navigation, our section proceeding Northward displays the lower members of the Vergent series in the following succession, descending:—

1. Yellowish-white and light-grey argillaceous flaggy sandstone, containing fossil *nuculæ, spirifers,* &c.
2. Dark-bluish grey thick flaggy sandstone, with ochreous shaly partings, fossils, encrinal stems, *spirifers, nuculæ,* &c.
3. Greenish-grey sandstone splitting as flags, argillaceous partings displaying vegetable branching stems.
4. Blackish and brown slaty sandstone with olive slate partings.
5. Greenish shale and dark vitreous flaggy sandstone; *fucoides velum.*
6. Dark-olive and brown shaly sandstone; fossils, *fucoides velum, spirifers,* and a spiral shell.
7. Olive flaggy sandstone, and slate with shaly partings.
8. Light greenish-grey and brownish flaggy sandstone, weathering buff-coloured and mealy.
9. Light olive slate, and flaggy sandstone.

Estimating the total thickness of the Vergent strata exposed on the North side of the central synclinal trough, where they are undisturbed by flexures, and where the dips are gentle and quite uniform towards the S., we find it somewhat exceeds 1800 feet.

The *Cadent upper black slates* are exposed for a distance, measured horizontally from the lowest bed of the Vergent, of 550 feet. This exhibits their whole thickness at this locality, which, with a dip of 25° to 30°, gives from 220 to 250 feet.

These strata, probably the equivalent of the Genesee slates of New York, are laminated and fissile, dark blue, and nearly black slates and shales, entirely destitute of fossils. They may readily be distinguished from the underlying Cadent shales by their nearly uniform fissile character, separating into layers thinner than pasteboard, and having nothing of the crumbling form of the shales.

The lowest strata exhibited in our section on the Lehigh are the Cadent olive shales. These are well exposed on the river opposite Weissport. Below the bridge the rocks comprising the uppermost layers of the group exhibit themselves as dark-bluish and brownish argillaceous shales, and yellowish soft shale, containing numerous fossil impressions, especially *aviculæ, nuculæ,* and *orthocera;* also stems. The cleavage, though discernible, is faint, dipping 60° South-eastward. The plane of bedding dips 30° Southward.

From a point 100 feet N. of the bridge at Weissport, occur alternating bands of olive and blue clay shales and black slates, to the end of our section.

Nearly half a mile above the bridge there is a complex anticlinal roll of the strata, by which the Cadent black slates are deflected from a Southward dip of 30° into a Northward one of 45°. From the bridge Northward to this point the dip fluctuates between 30° and 40°.

The cleavage is conspicuous above the bridge. Its plane dips South-eastward, though at varying angles. At first 50°, it soon becomes perpendicular, and then declines to 60°. In the vicinity of the anticlinal, its inclination changes from 60° first to 70°, then to 80° in the central axis, becoming flatter as we recede from it, and where our section ends it is not more than 45°.

DESCRIPTION OF THE STRATA AT THE SUSQUEHANNA GAP IN THE KITTATINNY MOUNTAIN. (See Section East Side of River.)

The Southern shoulder and main crest of the Kittatinny Mountain at the Susquehanna contain all the members of the Levant series originally existing in this district. From imperfection in the exposures, and a certain amount of faultiness or crushing consequent upon the somewhat overtilted position of the rocks, it is impossible to discern clearly the whole sequence of these strata. Evidently, however, there are two hard sandstone groups, and an intermediate softer, more argillaceous one, and these three probably represent the triple type of the series, which is so well exhibited further to the N.W. on the Juniata. Succeeding the Matinal slates, which constitute the Southern slope and foot of the mountain, the first members visible of the Levant series are a thin bed of coarse red conglomerate, hardly more than five feet thick, and in immediate contact a compact white conglomeritic sandstone, about 40 feet thick. These two beds are the cause of that remarkable shoulder or sloping terrace seen about two-thirds the height of the mountain, extending along it for several miles, both E. and W. of the river, a feature especially conspicuous in profile when we view either section of the mountain across the river, and beautifully distinct when the mountain is covered with snow, and the observer beholds it from the Capitol at Harrisburg, or any other distant point in the Cumberland Valley.

I am disposed to regard the rocks forming this hard rib as representing the Levant grey sandstone group, or lower member of the series, and to view the space between them and the hard rocks, forming here the summit of the mountain, as occupied by the shales of the upper group or Levant white sandstone. Beyond this blank space occurs the second or main hard group, that which outcrops along the crest of the mountain. This consists chiefly of beds of heavy red sandstone, with impressions of the marine fossil plants called fucoids, especially the *Arthrophycus Harlani.* I by no means feel assured that this group is the equivalent of the whole upper member of the series or Levant white sandstone so called ; on the contrary, it seems rather to represent only the upper or more fucoidal member of that group. Upon this interpretation we are left in doubt whether the main body of the white sandstone is here at all, or whether the already-mentioned bed next the conglomerate of the Southern rib of the mountain may not be a part of that rock.

Succeeding to the fucoidal red sandstones is a nearly blank space of apparently 40 or 50 feet, indicating the presence of an olive and yellow slate, which may be regarded as the lowest member of the Surgent series, and following upon this is a brownish sandstone, probably the Surgent iron-sandstone. Beyond this, again, are yellow and greenish shales, 80 or 100 feet thick ; these I regard as the iron-sandstone upper shales. Then comes a yellow and white sandstone, apparently the Levant ore-sandstone, extending nearly to the bed of the brook at the Northern foot of the mountain, followed by a thick succession of red shales and brown and greenish argillaceous sandstones, the representatives of the Surgent red shale.

Immediately succeeding these highest Surgent strata is a thin band of black fissile slate, evidently the Cadent older slate ; and to this succeeds, through a thickness of many hundred feet, the Cadent olive-shale group, including its remarkable rib of coarse grey sandstone, pitted with large cavities left by casts of *Delthyris* and other shells.

Reviewing this section, we notice first the extreme thinness of all the three lower typical members of the Levant series, also the very stinted development of the two lowest Surgent groups, especially in their slates and shales. We perceive, furthermore, that the iron sandstone is deficient in the type necessary to the presence of its block-iron ore, and that neither of the shales adjoining the ore sandstone exhibits any traces of the Surgent fossiliferous iron-ore. The only group of the series possessing a pretty full development seems to be the Surgent red shale.

There is manifestly an absence at the Susquehanna of the Pre-meridian limestone, the Meridian sandstone, and Post-meridian series, as the section, clear and satisfactory in this portion, fully testifies. Even the lower portion of the Cadent series is not here in all its typical development, for its black slate is thin and nearly gone, while the cement layers distinctive of that member in outcrops more to the N.W., are entirely absent.

VARIATIONS OF TYPE IN THE LINE OF OUTCROP.

Levant Series.—This great and persistent group of strata occupies, with the exception of one local belt, a single narrow zone, that of the Kittatinny or Blue Mountain. The only changes which it undergoes within the limits of the State are, therefore, in the direction of the line of outcrop. Adopting, as in all other cases, the ascending order in my description, I shall first exhibit the composition of the Levant white and grey sandstones.

Levant White and Grey Sandstones.—The sandstones which form the lowest natural subdivision of the Levant series are nowhere visible in Pennsylvania in such expansion or thickness as at the Water-Gap of the Delaware. Between the top of the Matinal slates and the base of the first or lowest Surgent slates, the entire sandstone mass, forming the broad and elevated crest, and higher portion of both flanks of the mountain, has an aggregate thickness of nearly 1000 feet. In this neighbourhood, and indeed as far South-westward as the Schuylkill, the group consists of grey and white quartzose massive sandstones, many of the coarse portions containing beds of grey conglomerate, in which the pebbles, consisting for the most part of igneous quartz and the harder materials of the Primal and Matinal strata, are frequently of the diameter of half an inch or more. There being no stratum in the middle of the group, equivalent to the Levant red sandstone, or Medina red shale of Niagara, the whole thick mass consists of only the Levant white and grey sandstones, or upper and lower members of the series. Some of the superior beds of the group exhibit impressions of the characteristic fossil, *Arthrophycus Harlani;* but this is the only fossil, and is very rare.

Traced South-westward, this great sandstone mass undergoes a marked diminution in its thickness, and at the same time becomes less coarse ; thus, at the Susquehanna, it appears nearly to reach its minimum. From the somewhat defective natural sections furnished by this and the other contiguous gorges in the Kittatinny Mountain, it is not easy to discover the constitution of the central and lower portions of the formation, or to ascertain what members, besides the upper or white fucoidal rock, and the lower or conglomerate bed, exist in these localities. The presence, especially in this inferior division of the formation, of pebbles of the harder materials of the Primal and Matinal strata is particularly worthy of note ; for viewed in connection with the uncomformable superposition of these beds upon the Matinal slates on the Hudson River, a fact discovered by me now many years ago,* and also in connection with the remarkable enlargement of the group towards the N.E., they become of great significance, suggesting the quarter whence the fragments were derived. Such conglomerates are to be regarded as among the most conclusive proofs of violent paroxysmal movements during the deposition of the Appalachian strata.

Surgent Slates and Shales.—In the region of the Delaware Water-Gap, the Surgent slates, the formations next overlying the sandstones of the Kittatinny Mountain, have a thickness of between 500 and 600 feet, but, as we might suppose, they do not possess the character of yellow and greenish argillaceous slates, so common to them elsewhere. The group here consists of grey and reddish sandy slates, alternating with grey and red argillaceous sandstones, and the whole mass shows an approximation in its composition to the next overlying member, the Surgent red shale. Towards the S.W. this mass acquires its more prevailing characters : the iron sandstone is not distinctly discernible at the Delaware, but is clearly recognisable at the Lehigh and Schuylkill ; is obvious enough at the Swatara, and on the Susquehanna has more than its average magnitude, appearing as a brown and grey sandstone, and producing a distinct terrace or bench on the North-western flank of the mountain. On the Susquehanna the three members of the iron-sandstone group measure together about 400 feet. Throughout this line of the Kittatinny Mountain, the whole group is unusually destitute of organic remains.

Surgent Red and Scalent Variegated Shales.—These constitute, at the Delaware, a mass

* See Second Annual Report (1837), and Address to Association of American Geologists (1844).

probably 1000 feet thick. Like the other formations here, the beds are more sandy than they are further South-westward, and as in all the S.E. outcrops, very deficient in calcareous matter. The group declines somewhat in thickness towards the Susquehanna.

A comparison of the above groups, the Surgent slates and shales in their South-eastern types, as represented in the Sections of the Delaware, Lehigh, and Susquehanna, with the type they wear in the parallel and more Northern outcrop of Montour's Ridge, as shown in the columnar Section in Book VI., Chap. I., presents many points of interest, both practical and scientific. The reader will notice that, in obedience to a general law, applying also to other strata, all the argillaceous formations are far more calcareous towards the N.W., and some of them even contain well-developed limestones. There is, moreover, a manifest and important increase in the quantity of ferruginous matter, equivalent, in fact, to the difference between the almost total absence of iron ores in the one district, and the presence of several continuous beds of great value in the other. This non-ferruginous character of all the formations of the belt of country just N. of the Kittatinny Mountain is to be lamented, for were the same strata as rich in iron along this outcrop as they are in other districts, the region, from its contiguity to the anthracite coal-fields, and the great markets of the sea-board, would be one of the most favoured in all the State for the manufacture of iron.

Pre-Meridian Limestone.—From the Delaware South-westward, this limestone, surmounting the Surgent and Scalent shales, extends with a gradually declining thickness as far as the Schuylkill, and beyond this point interruptedly to the Swatara; but from the Swatara to the Susquehanna it can scarcely be said to exist, and at this river no trace of it can be discovered.

Meridian Sandstone and Shales.—In the belt of country between the Water-Gap of the Delaware and the river Schuylkill, the Meridian series has its usual degree of expansion; but to the South-westward of the last-named stream, it gradually thins away, so that at Pine Grove it is hardly to be recognised, and at the Susquehanna is absent altogether.

Near the Delaware, the lowest or shaly member, under the form of a dusky-grey sandy shale, is not less than 130 to 150 feet; while the Meridian sandstone, which, throughout all the Eastern half of the State, is everywhere a much thinner formation, measures only from 20 to 40 feet.

At this locality, and at the Lehigh and elsewhere, the inferior or shaly member contains a thick layer of *chert*, usually of a light yellowish tint; and occasionally associated with the chert are deposits of the brown hydrated oxide of iron, of good quality, but generally too insufficient in quantity to prove of practical importance. The upper and more conspicuous part of the formation consists of a coarse calcareous sandstone, with included beds of very uniformly-grained conglomerate, composed wholly of rounded pebbles of quartz of the size of small peas. This rock lies in massive beds, which, at the outcrop, are divided by numerous cross joints into huge cuboidal blocks.

These blocks, some in their original place, some detached, cover always the crest of the ridge containing this formation, and impart to it in many localities a singularly rugged and picturesque outline. Those masses of the coarse beds which have long been exposed to atmospheric influences, and have lost by filtration all their carbonate of lime and their fossils, form a good material for the hearths of furnaces, especially where anthracite coal is employed, and a very intense heat, and much corrosive action, is to be encountered.

Post-Meridian Grits and Limestone.—These strata, met with in no other district of the State, are even in the region before us confined to the country between the Delaware and the Lehigh. The lower mass, which I have entitled the *Post-meridian Shales or Grits*, consists of dark grey or dusky shales, containing much sand, but not having the lithological character of a true sandstone. Near the Delaware this entire formation measures about 150 feet, but it rapidly thins away as we trace its outcrop South-westward. The largest division of the mass is a greenish-grey sandy shale, with some beds of argillo-calcareous sandstone. This portion contains the rather curious fossil called the *Fucoides Cauda galli*, from a fancied resemblance to the curving and spreading lines in the tail of the domestic cock. It is evidently some form of marine vegetable, and may be considered conventionally to be a *fucoid*, that is to say, a form related to the *sea-weeds.* A higher division of the formation, seen in New York, and called by the geologists of that State the *Schoharie Grit*, has not been recognised by us in the vicinity of the Delaware.

Post-Meridian Limestone.—This rock, the equivalent of the Onondaga and Corniferous limestones of the New York Geological Survey, ranging in thickness in that State from 80 to 20 feet, is well developed in New Jersey from the Water-Gap to the vicinity of Carpenter's Point; but in Pennsylvania it rapidly declines in dimensions as its outcrop is traced South-westward; and at the Water-Gap of the Lehigh it is hardly to be discovered. The formation is interesting from its fossils, and as an extensive and very persistent member of the great Appalachian succession of strata, as these are developed in New York and the North-western States; but it is of insignificant extent in Pennsylvania, and exerts but little influence on the physical features, and contributes almost nothing to the resources of the State.

It is essentially a Northern and Western rock, for it occurs nowhere S.W. of the Delaware, either in Pennsylvania, Virginia, or Eastern Tennessee. For the names and characters of its more essential organic remains, the reader is referred to the description of the fossils of the formation in the Palæontological division of this work.

The *Cadent Strata* of the Third District possess, in the region of the Delaware, very nearly the type which belongs to them in the North-eastern or Fourth District; while in the South-western part of the belt before us, they wear the characters which they possess West of the Susquehanna, or in the Fifth District. It seems unnecessary, therefore, to enter into a full description of their lithological and other features in this place, as these will be presented in the subsequent pages of this Third Book, and in Books IV., V., VI., and VII.

CHAPTER II.

REGION FROM CARPENTER'S POINT TO WALPACK BEND.

From Carpenter's Point to the Walpack Bend, the Delaware River flows upon the older Cadent strata. At the Southern abutment of the Milford Bridge, the Post-meridian fossiliferous limestone may be seen.

The streams that flow into the right bank of the river, come down from the foot of the lofty escarpment of the Pokono (Catskill), through the intermediate hills of older Ponent and Vergent rocks, by deep and narrow channels, in which occur innumerable cascades.* The hill-slope of the Cadent slates and shales facing the river is almost the only part of the country on the Pennsylvania side that can be said to be under cultivation. Those more to the N., up to the foot of the Pokono, are yet a wilderness. When cleared and settled, its inexhaustible resources of water-power will be turned to productive use.

The argillaceous Cadent shales which compose the first range of hills N. of the river, break with a splintery fracture, by innumerable cross-joints or diagonal cleavage-surfaces. The river-road, constructed of the weathered fragments of these compact blue and olive shales, is one of the best in Pennsylvania. Some of the strata contain numerous fossils.

Crossing the hills from Milford northward, the stratification first seen is almost horizontal. This proceeds from a broad anticlinal, the axis of which ranges Westward to the N. of the Bushkill Falls, and runs in behind the Pokono Knob towards the Long Pond. Further to the N. the rocks dip gently Northward, and red shale presently appears near an old saw-mill. A dull green compact sandstone is the prevailing rock. In the vicinity of the "Dark Swamp," near the saw-mill, bog ore is said to occur.† Crossing Broadhead's Creek, about five miles S. of the foot of the chief escarpment of the High Knob table-land (Pokono Mountains), we meet the first appearance of red shale, approaching the Pokono. It appears at the heads of all the creeks that flow into the Delaware, from the Northern margin of which rises the gigantic succession of steps that form the flank of the Pokono or Catskill Mountain. Here at the base are alternate bands of soft red shale, and argillaceous red sandstone ; still higher up are massive grey sandstones ; and finally, capping all, alternate beds of Vespertine white sandstone and conglomerate.‡

* Of these, the falls of the Sawkill and Ramyskill, near Milford, are well known. The Ramyskill leaps twice through a depth of 30 feet each pitch, and then flows over the rocks 400 yards to a precipice, down which it plunges about 110 feet, at what may be called either one or four leaps, into a winding chasm of such unusual straitness that it is difficult to obtain a point of view, as the whole is sunk in the depth of the forest.

There is a waterfall of 30 feet upon the Bushkill, five miles above its mouth. A still finer one occurs on Marshall Creek, a few miles from Stroudsburg. One upon the Sambo Creek, but difficult of access, will also repay those who are willing to traverse the woods in which it lies.

† The same ore seems to be spread very widely over the State, appearing, for example, upon Larry Creek above Jersey shore, in the Sixth District.

‡ Between these Vespertine sandstone strata are to be seen in many places thin seams of bituminous slate, black and soft, which, being bordered by the red shale below, and the conglomeratic rocks above, have induced a belief that they are of the true coal-formation, leading to fruitless search for coal. The black slates of the older Cadent rocks have originated a similar practical delusion.

The outcrop of these last is at once the summit of the Pokono Mountain and the margin of the elevated Wallenpaupack plateau, which stretches Northward, covered with beech-woods, and only inhabited as yet by shingle-cutters, lumbermen, and hunters. This escarpment is perhaps 1000 feet in height, and overtops the Kittatinny Mountain by several hundred feet. At the High Knob, the line of outcrop falls back Northward, almost facing the E. for a few miles, and then resumes with a less lofty summit-outline its North-eastward course to cross the Delaware.

Upon the Shohola are seen the dull green sandstones of the Vergent group, cleaving in very thin plates, the surfaces of which show flakes of mica. About the Shohola Falls appear rolled fragments of the red shale and sandstone in place. A calcareous conglomerate stratum, in thickness from two to three feet, outcrops at Darling's, a mile and a half N.W. from Shohola Falls, around the margin of what has once been a shallow lake or natural pond. It is a compound of small fragments of limestones, slates, and sandstone cemented with oxide of iron, but not calcareous enough for the limekiln.

These upper Vergent and lower Ponent strata extend horizontally to the Lackawanna.

Three miles N.E. of Milford, at the mouth of a small stream, there is a deposit of black oxide of manganese, among pebbles of broken and rolled blocks and sand, the debris of the sides of the ravine.

CHAPTER III.

FROM THE WALPACK BEND TO THE DELAWARE WATER-GAP.

Fifteen miles above the Delaware Water-Gap the river leaves the valley of the Cadent lower black slates and Cadent olive shales, turns short to the left, traverses the double ridge of Post-meridian and Pre-meridian limestones, and flows along the valley of the Cadent marls and shales. The following Section represents the cut made by the river in this bend :—

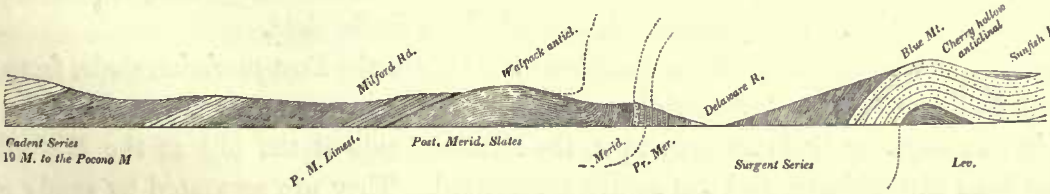


Fig. 33.—Section S.W. of Walpack Bend.

The river, sweeping by the little village of Bushkill, makes its first bend through the upper or Post-meridian limestone, round a low point coming from the E.; it then makes a longer but sharper bend round the end of a long high point coming from the W., and formed of the lower or Pre-meridian limestone. This point is called the Hog's-back, which is a ridge of about 300 feet in height, and half a mile long, and so sharp along the summit that there is but room enough for a narrow road. The slopes on either side incline 30°, and are covered with woods. From its Southern foot there stretches a diluvial bottom ; its Northern is washed by the river in the bend.

The Hog's-back Ridge is formed by the hard outcropping edges of the Pre-meridian limestone finely exposed. These are massive, coarse, and sandy. They alternate with and are underlaid by sandstones of moderate coarseness of texture and rather slaty. The limestone-beds are from 2 to 15 feet in thickness, and some of them full of chert. Much of the intercalated rock is a coarse silicious slate of uneven cleavage.

At its Western part the Hog's-back spreads into a broad double ridge, the Northern crest of which displays the Post-meridian limestone strata. The Cadent black slates succeed these in the valley along which the road to Stroudsburg passes, and this valley is overlooked again from the N. by an escarpment of Vergent flags.

In the accompanying section the Walpack axis, which at the bend is seen in the body of the Blue Mountain, has moved out into the valley, and separates the outcrops of the Pre-meridian and Post-meridian limestones more than a mile asunder; while another axis has taken the place of the former in the mountain, and issues from it in the long red hill that runs Westward from the Delaware Water-Gap, along the Southern side of Cherry Creek. The Walpack axis seems to flatten entirely out at Stroudsburg.

About five miles E. of Stroudsburg, on the river hill, blue and massive Post-meridian limestone is visible in a quarry. It is 20 feet thick, is nearly vertical in dip, and is overlaid at some distance by a massive, coarse, and apparently calcareous conglomeritic sandstone with irregular cleavage. The summit of the ridge (Godfrey's), on the Southern slope of which the quarry lies, is composed of a rough silicious shale, with a cleavage dipping S. 70°, and easily separable into lenticular pieces, and sometimes heavily charged with lime.

At the falls of the Middle Bushkill, three miles from the Delaware, are two layers of fossiliferous limestone, separated by a layer of slaty fossiliferous sandstone. Beneath the lowermost is a slaty rock full of shells, based upon slates. Above the uppermost are massive slaty sandstones, with a few fossils.

The rough, slaty, calcareous Meridian shales, filled with black chert, occupy nearly a mile in width of gentle outcrop.

The Meridian sandstone is seen at the summit of a high hill upon Marshall's Creek, dipping Northward. It stretches along the crest as a wall from 10 to 20 feet in height, and cannot be more than 35 feet thick. Everywhere it is overlaid by a fissile slate.

To the Northward of the Meridian sandstone are hills of the Post-meridian shale, from 100 to 200 feet in height, with the Post-meridian calcareous layers in the upper part. These layers are exposed in five steps or little terraces upon the Northern side of the hill at the Milford Road, four miles from Stroudsburg, and dip gently Northward. They are separated by sandy slates.

They appear again upon the road up Broadhead's Creek in the fields upon the left bank; also at a quarry on the right bank near the Big Spring. Eighteen feet of an impure limestone, dipping 20° to 30° N.W., is there exposed.

The same outcrop of Post-meridian limestone sweeps round the town of Stroudsburg, and is visible on the road to the Wind-Gap.

CHAPTER IV.

FROM THE DELAWARE WATER-GAP TO THE WIND-GAP.

At the Delaware Gap a North and South fracture appears to traverse the various formations from the Matinal slates to the Surgent shales, and the rocks of the Eastern wall of the pass are all thrown upward, or shoved toward the N. a distance of several hundred feet. The two sides of the Gap seem, therefore, not to correspond. (See sketch of the Water-Gap.)

Godfrey's Ridge, which ranges along the Northern side of Cherry Hollow, is deflected Northward opposite this fracture by nearly the same distance. Broadhead's Creek issues through this ridge by a gap produced along the line of fracture just as the Delaware follows the same break through the Kittatinny Mountain.

These gaps yield exposures from which the following Section has been constructed.

In the Gap *the Levant White Sandstone Strata* dip at an angle of 50° N.N.W. The mountain summit on the Western side is stated to be 1600 feet above the sea level; it rises about 1200 feet above the water in the river.

The Surgent Red Shales occur at the village of Dutotsburg, dipping 25° to 35° N.N.W. They are almost uniform in tint, blue and yellow shades seldom appearing in the mass. Cherry Creek and the Aquanchicola flow in these shales, the one Eastward into the Delaware, the other Westward into the Lehigh. The Westward declension of an anticlinal axis here gives a curve to the strike of these shales.

The Pre-meridian Limestone, separated from the red shale where last exposed by an interval of several hundred feet of unknown rocks, appears at the quarries W. of Dutotsburg on the Western side of the fracture, and at Bell's Quarry, near the bridge over Broadhead's Creek, on the Eastern. These argillaceous slaty limestones are of a dull blue or grey colour, with numerous diagonal or cleavage-joints, some of the thicker being almost black and of a compact texture, and the uppermost abounding in fossils.

Ferruginous soil occurs along its outcrop in many places, and loose lumps of carbonate of iron, sometimes of several pounds weight, lie on the surface, as at Bittenbender's, five and a half miles S.W. of Stroudsburg; but there is no sufficient depth of ore-ground over this limestone, or at the base of the hill, to warrant any sanguine anticipations of the discovery of a profitable body of iron ore.

The outcrop of the limestone is half-way up the Southern slope of Godfrey's Ridge, which is 400 or 500 feet high, but is generally broken down, sometimes to half this height. Where the Wind-Gap road crosses the ridge five miles from Stroudsburg, the quarries are on what is there the summit, or even to the N. of it, the sandstone axis of the ridge lying at a lower level still further N. At the head of Cherry Hollow, eight miles W. of the Gap, the Cherry Hollow anticlinal enters the formation, and flattens it out, causing it to describe a kind of goose-neck curve, the Western point of which is presented towards the lake between the turnpikes. Where the Creek issues Eastward from the long narrow vale of red shale, and sweeps round the base of a bold promontory facing the Blue Mountain, the limestone is finely exposed for 20 feet in thickness, dipping 20° W.S.W., an unusual direction. This is the dip of the synclinal trough, in the axis of which it here lies. It soon resumes its steep N.N.W. dip as it ranges along the bluff slope of this ridge towards the Wind-Gap. Its dip along Godfrey's Ridge varies from 70° to 85°.

The Meridian Sandstone, a coarse, cherty, semi-calcareous conglomeritic rock, forms the backbone of the Limestone or "Godfrey's" Ridge, and outcrops visibly in rugged cliffs at all the more eminent points along the line from the gap of Broadhead's Creek to the remarkable mural stony hill called Steinberg, in front of the Lehigh Gap. These points form a chain of sharp ragged eminences, which are generally shaded by a growth of small spruce and hemlock (*Abies Canadensis*). The rock varies but little from an average thickness of 30 feet. Where it is slightly weathered by long exposure, it becomes of an open and loose texture, and where greatly decomposed, falls into sand in which lie fragments of its more refractory imbedded chert.

Details.—At the end of the hill below Bell's Mills, on Broadhead's Creek, a mile above Dutotsburg, the sandstone is seen in a bold ledge, 30 feet thick, and dipping 12° North-north-westward. But for eight miles along the top of the ridge, proceeding Westward, no good exposure of its outcrop is observable; the silicious Meridian dusky shales beneath it, and the silicious Post-meridian grit slates above it (each formation probably from 200 to 300 feet in thickness), compose, to all appearance, the whole broad summit.

Opposite Stroudsburg 8 feet of the cherty conglomerate is exposed, mixed with spar, but the chert is less abundant than usual. Eighty yards to the N. of it there is a rib of shaly sandstone, 40 feet thick, projecting above the surface, with a nearly vertical dip.

Eight miles from Broadhead's Creek, however, a point of the sandstone juts out in a remarkable manner, presenting the appearance shown in the figure.

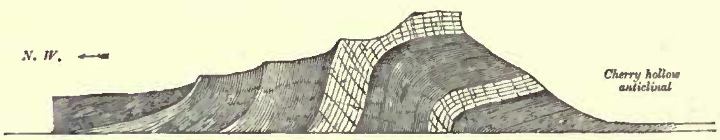


FIG. 34.—Section—Godfrey's Ridge, S.W. of Stroudsburg.

It displays a cliff to the Southward 200 feet in length and 40 feet in height (apparently the whole thickness of the formation), and based upon the calcareous Meridian slates that overlie the limestone half-way down the slope. This is very evident at its Western end. The cliff consists of coarse sandstone and dark grey chert in nearly equal proportions, the layers being from a few inches to 3 feet in thickness in regular alternations. The dip is from 12° to 15° Northward. But descending the Northern slope the strata are seen dipping almost vertically, and forming a rocky terrace. The rest of the slope consists of Post-meridian slates, dipping 75° to 80° N. In the valley at the foot occurs the Post-meridian limestone, impure, slaty, and containing chert.

Half a mile further W. another section across the ridge displays the presence of a small roll, to which the more prominent features of the section last described are due.

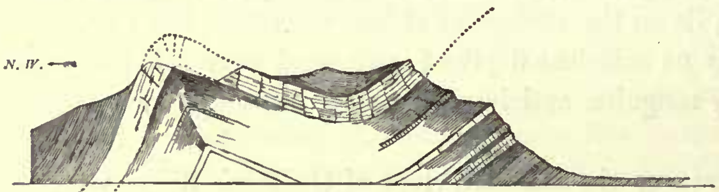


FIG. 35.—Section—Godfrey's Ridge, S.W. of Stroudsburg.

The Section represents the ridge East of the road near Storm's Tavern. The limestone observed near the summit of the ridge, beneath the Southern outcrop of the sandstone, abounds in Pre-meridian fossils and in chert. The sandstone at the summit is 30 feet thick as exposed, but may be more, and dips Northward 35°; much chert in fragments lies behind it to the N. Bands of chert from 3 to 12 inches thick are interstratified with the mass, and a slightly calcareous silicious slate occasionally appears as an additional element. The whole is fossiliferous.

A second summit, 400 feet to the Northward of the first, containing the same strata, rises with a S. dip of 25°; but only to descend again in a third line of outcrop, and an almost vertical dip 100 feet further N. Thus we have a small and shallow synclinal flexure, filled with fissile, thin, Post-meridian slates occupying the summit of the ridge; and upon its Northern brow a smaller, sharper anticlinal flexure, breaking the Meridian sandstone, and allowing the underlying Meridian slate to appear. The Northern slope is, of course, composed of Post-meridian slates, and at its foot flows M'Mickle's Creek, north of which runs the outcrop of the Post-meridian limestone.

Thus along the crest of the limestone ridge, which everywhere faces the Blue Mountain, this remarkable formation may be traced from summit to summit, in the numerous points at which it comes to the day. It appears in broken cliffs on the top of the hill N.E. of the limestone quarries, three miles E. of the turnpike, and N. of the road from Storm's Tavern to the quarries. Where the turnpike crosses the ridge, a fair white chert, in fragments, fills the soil, between the limestone quarries and the road.

The Post-meridian limestone overlies the Meridian sandstone at an interval of 300 feet. The space is filled by dark grey sandy slate, with chert. On the S. side of the creek, nearly opposite the town of Stroudsburg, is an exposure of the limestone, which contains black chert, and abounds in fossils. It dips gently (10°—15°) Northward, and is at the Northern edge of a very level plain, 400 yards in breadth, extending to Godfrey's Ridge.

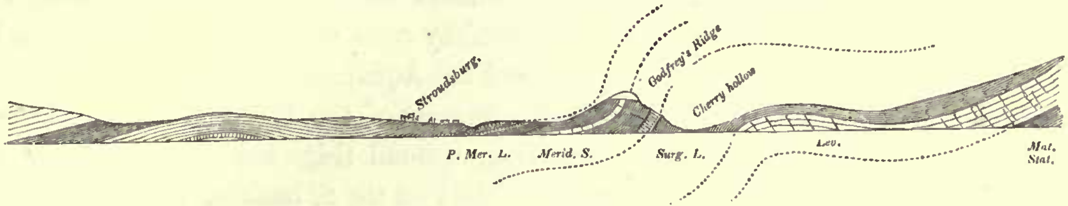


FIG. 36.—Section through Stroudsburg across Walpack Axis.—1 *inch* = 1½ *miles.*

The stone of some of the lower layers has been burned, but it does not make a superior lime.

On the road between the Delaware Water-Gap and Stroudsburg, the Meridian sandstone is to be seen on the South side of Fox Hill, dipping 40° S. Higher up the hill it is overlaid by the Cocktail grit, or Post-meridian shales; and crossing the hill we meet this rock on the North side of the Gap again, dipping 70°, 80° to N., 20° W., with cleavage-planes dipping 50° to S., 10° E. Its thickness is not all seen, only 50 feet being exposed. The Post-meridian or Corniferous limestone, full of nodules of black chert, overlies it on its North side, and dips also 70°, 80° N. It is an interesting fact that these chert nodules lie with their axes in the plane of the cleavage, and not in that of the stratification. As it is generally admitted that such nodules are true *concretions*, segregated in the planes of bedding, it is difficult to conceive how these, once so formed, could have been redistributed and compressed in the direction of the cleavage by a mere mechanical force; they must have concreted during, or subsequent to, the production of the cleavage fissures.

At the Northern base of Fox Hill the Cocktail grits dip vertically, or 85° N., and over them to the N. the corniferous limestone occurs again with its chert, containing zoophytes and fossils.

Beyond the ridge a flat plain succeeds, covered with diluvium, overlying the Cadent older black slate. This rock is seen at Stroudsburg, at the Falls of Broadhead's Creek, where 100 feet of it is exposed, dipping 30° to N., 20° W., with its cleavage-planes, as usual, dipping S. about 50°.

The black slate is half a mile from the Northern foot of Fox Hill; therefore there are probably changes of dip, or anticlinal flexures, in the intervening space.

The cleavage on Broadhead's Creek, between the Bridge and Experiment Mills, dips S. 40° E., and a set of close parallel joints, also like cleavage, S. 30° E. The bedding here is horizontal, or very gently S. The surfaces display the *Fucoides Cauda Galli.*

When we reach the meridian of the North and South Turnpike from Nazareth, through the Wind-Gap, to Montrose, the topography simplifies itself again, as the West end of the Walpack flexure is lost in the plateau of Cadent shales and flags that circle round the Pokono Knob, while the Lehighton anticlinal augments continually Westward, forming a well-defined wide vale of Cadent slates, through which flows the McMickle's Creek Eastward, and Big Creek Westward into the distant Lehigh. At first the Post-meridian limestone outcrops on each side of this valley, but not far to the Westward these two outcrops unite over the axis. At one place the S. outcrop is seen to dip 50° S., at another place only 20°. The N. outcrop is covered generally by the stream.

The Vergent Flags, wherever they outcrop, form a lofty escarpment, perhaps 600 feet in height, devoid of all harshness of outline, with an even summit, and a slope ploughed at regular intervals into descending ravines, between which cultivated fields usually occupy the declivities. A wide and fertile valley lies at the foot, and an arable table-land often slopes gently back from its brow.

Such an escarpment crosses the Delaware River at Carpenter's Point and Broadhead's Creek, two miles N. of Stroudsburg. The Pokono Creek issues from it. It looks down upon the valley of the Lehighton anticlinal, and runs on to cross the Lehigh above Weissport. Its rocks all dip Northward, at first gently, at last steeply, as the Lehighton flexure includes finally an inversion of the strata. Larry's Hill offers a fine view of this escarpment. A synclinal basin, with gentle North and South dipping Cadent, Vergent, and Ponent rocks, runs from within two miles of Stroudsburg west across the Lehigh to the Little Schuylkill. By examining the general Sections II. and III., where they cross it, and the Map, its features may be easily understood. The broad ridge which fills it—Fireclay Hill, Pine Ridge, Mahoning Hill, &c.—presents two such escarpments as that just described. One of these looks towards the anticlinal valley of Pine Creek, a branch of the Aquanchicola, and is traversed by cross vales, through which one branch of McMickle's Creek, and branches of Big Creek and the Aquanchicola, flow.

Around the E. end of this synclinal ridge the outcrop of the Post-meridian limestone may be traced dipping 10° N.N.W., and thence W. along a small ridge at the base of its S. escarpment, but with great difficulty. It is certainly visible on the S. bank of Pine Creek, at the N. foot of the limestone ridge opposite Smith's Gap. It probably occurs again near Clarissa Furnace, six miles from the Lehigh River, but has not been as yet recognised further W.

Ponent Series upon the Wilkesbarre Turnpike.—The Ponent red shales are first observed at a point a mile and a half S. of Merwine's Tavern, or from three to four miles before reaching the foot of the Pokono Mountain. They stretch E., to fold round the base of the Pokono Knob,—where they may be studied upon the N. and S. Turnpike at the Tanneries—and along the Pokono Creek, and W., to fill the Cove behind the Big Creek or Kettle Mountain, around the end of which they bend, and cross the Lehigh River above Lehighton. The whole district of Vergent and Ponent rocks N. of the anticlinal valley of Big Creek and McMickle's Creek is still a partial wilderness. A few settlements have been made upon the head-waters of McMickle's Creek, and along the turnpike. Through this there ought to pass in an E. and W. direction the anticlinal axis which, issuing from the Nesquihoning Mountain beyond the Lehigh, cuts off the synclinal Kettle Mountain by a narrow cove from the regular escarpment of the Pokono. This axis, however, cannot be traced distinctly E. of the Wilkesbarre turnpike. It spreads the rocks out almost horizontally, and by its termination no doubt causes that advancement S. into the rolling plain below of the escarpment of the Pokono, which may be remarked upon the map in the space between the turnpike and the head of McMickle's Creek.

The Pokono Knob is occasioned by a similar broad undulation, running into the great table-land behind it; it is but a remnant of the table-land left along the middle line of a synclinal trough, much more shallow and even in its course than that of the Kettle Mountain, which deepens so rapidly W. as to allow the Seral series and its coal-measures to rest within it at the Lehigh.

The subsidence Eastward of the numerous flexures of the anthracite coal region of the Broad Mountain and the Beaver Meadow basins, spreads out the elevated table-land of Ponent sandstones, capped here and there with Vespertine conglomerate, which extends from the escarpment of the Pokono north to the Bald or Wyoming Mountain, and overlooks the Wilkesbarre coal-basin. Part of this plateau lies upon the West side of the Lehigh, and is called the Nesquihoning Mountain. Around its West end bends the Locust Valley.

Pimple Hill rises as a solitary knob upon this plateau W. of the turnpike, and being several hundred feet in height, it overlooks the whole district. Upon its sides are fragments of red shale, and at its top a conglomeritic red sandstone, one of the upper members of the Ponent series.

The whole of this region is an almost unreclaimable wilderness, drained by the two great water-courses of the Wallenpaupack and the Lehigh, and covered with a growth of hemlock, spruce, and white pine, and, along the Northern margin, with beech. Laurel thickets fringe the streams flowing into the Lehigh; swamps are numerous; many square miles are covered continuously with low thickets of whortleberry bushes; other extensive tracts with scrub spruce. One part of it is called the Shades of Death. Settlements have here and there been effected, but there are chiefly a few saw-mills around its edges. Some hunters' and shingle-cutters' cabins in its depths are almost the only other inhabited places.

CHAPTER V.

FROM THE WIND-GAP TO THE LITTLE SCHUYLKILL.

At the Wind-Gap an anticlinal issues from the Blue or Kittatinny Mountain, and dies out in a hill of Surgent red shales, the point of which the turnpike crosses. This expiring axis causes the limestone ridge to be deflected more to the Southward.

Scalent limestone is quarried opposite the Gap, near the summit of the ridge.

The Southern escarpment of the Vergent flags is ascended, on the Wilkesbarre turnpike, six miles from the Gap, the grey sandstones dipping uniformly 25° N.N.W., almost to the Lehigh. But at its foot there is a lower ridge of Cadent shales, containing an argillaceous sandstone filled with fossils, and by them everywhere traceable Westward. At Pine Grove they become even more abundant. This sandstone lies not far below the base of the Vergent flags.

Here the synclinal trough is very regular. The Southern dips of its Northern escarpment are 20° to 25°. On approaching the Lehigh, while these flatten to 50°, those on the Southern side steepen to even 70°.

The accompanying diagram exhibits in contrast the synclinal flexures at the two distant

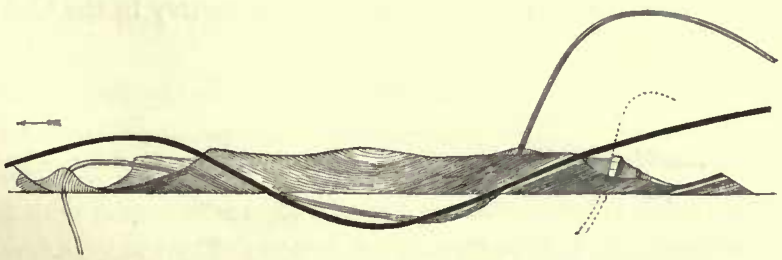


Fig. 37.—Flexures at Wind-Gap and at Lehigh Water-Gap compared.

points. It is to be remarked that the flexures increase both in number and force as we approach the meridian of the Schuylkill.

Pine Creek flows along the deep and narrow vale of the Cadent older black slates, with the outcrop of the Pre-meridian limestone upon their Southern side, as may be seen opposite Smith's Gap.

The *Wind Gap* is a deep undulation where the Blue Mountain is cut down to half its height. It divides the head springs of the Aquanchicola, M^cMickle's, and Cherry creeks, which all take their rise in its immediate vicinity. Its whole appearance is unique when compared with most of the Appalachian gaps. To a traveller reaching the summit of the pass, the sudden view of the open country to the S. is striking.

The spur which the Kittatinny Mountain projects Eastward between the Wind Gap and the Delaware Water-Gap, is a fine example, both in geological structure and topographical features, of a synclinal mountain, and to an initiated eye is visibly such at a distance of several miles.

Upon its brow is a white band, marking the outcrop of the Levant white sandstone, which forms its summit, and which has protected from further denudation the Matinal slates which compose its mass.

Smith's Gap is a slight depression in the summit of the Blue Mountain; opposite it are quarries of limestone.

Little Gap is a notch in the mountain, perhaps 300 feet deep. Hereabouts the great flexures become stronger, the Northerly dip steepens, and the mountain is gently deflected from a S.S.W. to a more Westward course.

In *the Lehigh Water-Gap* the dip does not exceed 35°. It is somewhat fluctuating, and continues so for several miles further W.

At *Knowle's Gap* the dip is quite gentle, and the mountain again bears away South-westward.

The Bake Oven Knob is a prominent point upon the summit-line of the mountain, visible from a great distance, yet it is scarcely more than 100 feet higher than the general level. It is made more conspicuous by the proximity of a slight indentation on its Eastern side. An immense amphitheatre has been excavated in the Southern side of the mountain by rushing waters.

A precipice of 150 feet, the outcrop of the Levant white sandstone, overhangs this bowl-shaped hollow on the W. From the angle of this cliff there is a fine view of the Great Appalachian Valley south, and of the narrow ridges and broad table-lands to the north.

Valley North of the Kittatinny Mountain.—Opposite the Lehigh Water-Gap, Stone Ridge is crested by a long and rugged outcrop of the Meridian sandstone, rising from the summit in a wall of almost artificial aspect, from 20 to 50 feet in height. From the Northern foot of the wall stretches a level plain to the summit of the Vergent flags. From its Southern foot descends a rocky slope, at the bottom of which, by the roadside, is a quarry in the Cadent limestone.

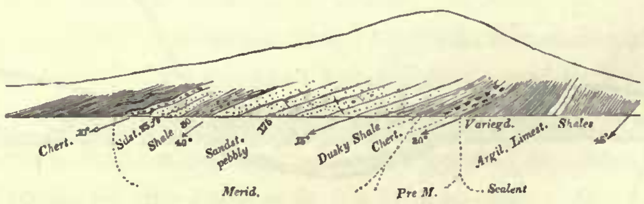


FIG. 38.—Section of Stone Ridge at the Lehigh.

This wall of sandstone runs along the summit Eastward; but at Clarissa Furnace the ridge on the Western side of the gorge seems chiefly to consist of Cadent slates, N. of which occur beds of limestone. On the Eastern side, cliffs of the sandstone are abundant, even toward the Northern side of the ridge. There is probably here a cross fracture. Three miles E. of this the Pre-meridian limestone is quarried.

The limestone quarried by the roadside two miles W. of the Lehigh Gap has overlying it a stratum of conglomeritic sandstone, forming a low ridge. It is from 25 to 50 feet in thickness, and is interstratified with beds of chert. The sandstone is made up of grains of sand, loosely cemented in earthy matter. Its colour is a yellowish white, sometimes tinted red and sometimes quite dark.

The Lehigh River, after leaving the gap of the double-crested Mahoning Mountain, composed of Vespertine conglomerate and Ponent sandstone, all nearly perpendicular in dip,* traverses the little valley of Ponent red shales, and develops the Vergent and Cadent series down to the lowest rocks appearing upon the sharp Lehighton axis. S. of the axis it displays them again in a reverse order, and in fine exposures dipping 30° S. It sweeps diagonally through the wide synclinal basin, exposing minor rolls and little faults, and then breaks through Stone Ridge into the Surgent red shale valley at the Blue Mountain.

This synclinal trough has traces of Ponent rocks along its central line, from as far E. as the Wilkesbarre Turnpike. Much red sandstone and shale belonging to that series are seen along its deepest parts upon the Lehigh. But a few miles W. of the Lehigh, this synclinal trough of Ponent rocks forms a separate ridge between two broad high ridges of Vergent shales and sandstones. As it approaches the Little Schuylkill, the Ponent ridge is divided by a small anticlinal axis, which originates but two miles E. of that stream.

While the Lehighton anticlinal, after traversing the whole Mahoning Valley with vertical dips on the Northern side, expires as it approaches the Little Schuylkill, another rises S. of it, and elevates the Northern part of the Wildcat Mountain, and forms the Northern slope of the Tuscarora flexure in the Sharp Mountain. A third shorter flexure, running parallel and close to the last named, crosses the river near it, and elevates the Southern end of the Wildcat Mountain, and thence enters the coal-basin through the other spur of the Sharp Mountain opposite Middleport. The Wildcat Mountain is, therefore, the great Ponent and Vespertine range of the Mahoning Mountain, broadened and deflected Southward by the passage of these two anticlinals.

CHAPTER VI.

FROM THE LITTLE SCHUYLKILL TO THE SWATARA.

Twelve parallel Anticlinal Flexures, of various lengths and breadths, cross the Little Schuylkill River in the region between Tamaqua and Port Clinton. Two of these—the two Northernmost—have already been described; they enter the Wildcat Mountain. This, when beyond the reach of their influence, ranges in a straight line W.S.W., under the name of the Second Mountain, and is broken only by the gaps of the Schuylkill and the West Branch of the Swatara rivers. Its overturned Ponent and Vespertine rocks, dipping 80° E.S.E., are affected, first by the tenth flexure, which dies out two miles W. of McKeansburg, after dipping both ways 45°; and again by the next, or ninth flexure, which runs past it, through the Red Hill and under the villages of Orwigsburg and Schuylkill Haven, through Long Run Ridge, expiring in the Second Mountain, six miles W. of Pine Grove.

The eighth, seventh, and sixth form together a single compound flexure, and with the fifth, fourth, and third, enter the Blue Mountain from the E. by four coves, and issue from it on the W. by four short and bold spurs or knobs, round the foot of which the Little Schuylkill flows

* See general Section, No. III.

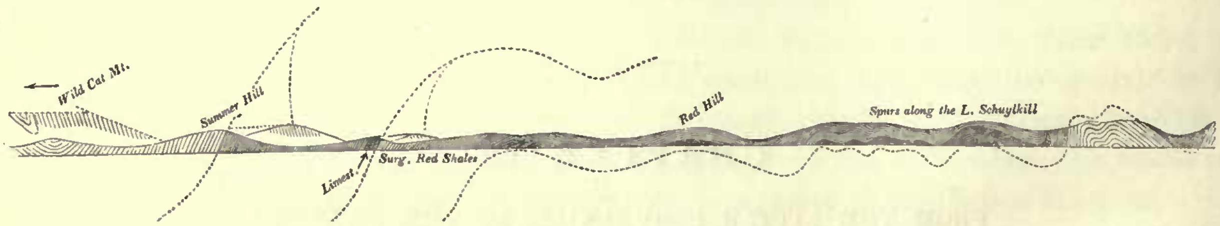
above Port Clinton. These axes die out rapidly in the Pre-meridian limestone ridge, and against the Scollop Mountain, which is the semicircular termination of a long synclinal flat ridge of Vergent and Ponent rocks, the Western point of which is W. of Pine Grove. The Northern escarpment of this basin is named Schuylkill Mountain, and its Southern escarpment Summer Hill. Along its centre runs a narrow belt of Ponent sandstone, similar to that described in the last Chapter as occupying the synclinal basin S. of the Lehighton axis—a ridge, geologically quite similar to it, has the local name of Summer Hill, which is the continuation of the Little Mountain across the Little Schuylkill eastward. The resemblance of the thorough-cut of these rocks made by the main Schuylkill to that made by the Lehigh River is very remarkable (compare general Sections, No. III. and IV., where they cross the two basins). The same section will almost answer the purpose of describing either.

The second flexure crosses the Little Schuylkill near the third, and, with the latter, elevates the isolated mountain in the forks of the rivers. It dies out in the valleys, a little above the mouth of Bear Creek. It is visible at the Foundry in three natural exposures or arched cliffs, one above the other.

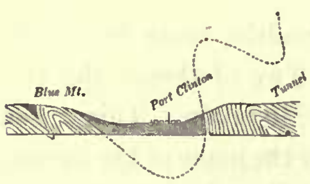
The first anticlinal enters a little cove or offset at the end of the long synclinal mountain which extends out from Port Clinton eastward. It traverses the ridge on the Southern side of the Surgent Red Shale Valley of Roaring Run ; crosses the Schuylkill River below Port Clinton, above the Tunnel, where its South dip is 12°, and its North dip vertical, deflecting the Blue Mountain. The Hole Valley, near the Swatara River, contains another anticlinal ; and the Hole Mountain is simply a synclinal outlyer of Levant white sandstone, S. of the main Kittatinny Ridge.*

These flexures may all be studied satisfactorily in the natural and artificial exposures at the

Fig. 39.—Section on the Little Schuylkill through Port Clinton.—1 *inch* = 1 *mile.*



Little Schuylkill. Their Northernly dips are generally nearly or quite vertical, as seen in the accompanying Section.



Let us now trace the several strata from the Eastern side of the Little Schuylkill westward.

1. *Surgent Series.*—The Little Schuylkill flows in the Surgent red shales, but cuts through and exposes the underlying ore sandstone, at the axes of the anticlinal flexures. The upper boundary of the red shale will be appropriately

* The topography of the portion of the Blue Mountain here described, *as seen from the W.*, will be more distinctly understood by consulting the background outlines in general Section IV. Either the Spitzburg,—a high cone rising from the bank of the Maiden Creek, North-east of Hamburg,—or the Western end of the Dutotsberg (Spitzberg on the State Map)—a long and broken ridge lying between the fourth and fifth anticlinals—as they approach the Lehigh, will afford the spectator remarkably beautiful views of the corresponding spurs and coves upon the *Eastern* side. The whole forms one large cove, drained by the channels of the Antiluna or Maiden Creek. A long line of broken hills running out toward the Lehigh, seems to mark the course pursued by the synclinal basin on the South side of the third anticlinal flexure. Similar parallel lines of hill, more or less distinct, follow the course of the other flexures. The general direction is N. 83° E. The dips in this great cove of Matinal slates are very steep, but difficult to detect and follow.

described by tracing the outcrop of the limestone layers overlying it. It forms the rolling plain W. of the Little Schuylkill on the turnpike, forms the Red Hill, and the hill at McKeansburg, and comes to a point along the axis of the ninth anticlinal at Schuylkill Haven. It fills the ravines between the mountain-spurs, and forms the vale in which the main Schuylkill has its deep winding channel to Port Clinton. It then passes on Westward at the Northern foot of the Blue Mountain.

2. *The Scalent Limestone* outcrops along the limestone ridge, and is quarried on the North-eastern side of the village of McKeansburg. On the return of the ridge Eastward, along the Southern side of the axis, it is quarried to the S.E. of Orwigsburg, 20 feet thick, and dips 30° S. 30° E. Its quality is good. It sweeps round S.E. and S., and has been quarried at Wolf's Rocks, near the line of the fifth axis; it crosses the Schuylkill near the mouth of Pine Creek, and ranges Westward, dipping 20° N. 30° W., and outcrops all along between the summits of the broken ridge at the foot of the Blue Mountain, the Northern half of which is composed of a yellow massive sandstone. The limestone is opened in a gap in this ridge S. of Schuylkill Haven, and is accompanied with bog ore. At the Swatara this ridge, after being wholly swept away at intervals for miles, becomes very high, and the limestone is again seen dipping 25° N. 30° W., on the Stumptown road. Two beds of it appear in the little gap a mile or two further E.; six miles further W. it is of good quality, and 30 feet thick, dip 45° N. 30° W. At the Swatara Gap it is 25 feet thick, but it is inverted, dipping, 85° S. 35° E.

The valley along the Northern side of this limestone ridge from the Schuylkill River Westward is sandy and barren, and occupied by the outcrop of the Cadent shales and slates, overlooked from the N. by the high escarpment of the outcropping fossiliferous Vergent flags. These limestone layers are best studied, however, where the prolongation of their double outcrop by the Orwigsburg, or ninth anticlinal, carries them across the Schuylkill. Their last appearance at the surface is about four miles W. of Schuylkill Haven.

At *Schuylkill Haven*, midway between the South-dipping (25°) Cadent and Vergent strata of the Schuylkill Mountain, and the vertical or overturned (80°) South-dipping Vergent strata of the Little Mountain, there runs the sharp-folded flexure through the axis of Long Run Ridge, and here the limestone appears in thin layers, alternating in the upper part of the mass with grey argillaceous sandstone, and in the lower with green and red shales. Still nearer the axis, which crosses one edge of the town, the Surgent red shale underlies the limestone in an exposure 60 feet thick.

One mile to the E. of Schuylkill Haven the position of the limestone marks the axis of the flexure, dipping Southward with the inclination of the surface, and Northward with increasing steepness. On both sides the hill is covered with the fragmentary soil of a deep red rather compact sandstone; so also is the Southern slope of the next little hill to the N. This red sandstone can be traced along the hill-side S. of Orwigsburg.

On the Eastern side of the ravine containing the exposures last described, the limestone is again seen dipping 30° S., and underlaid by a yellow sandstone, externally reddish, and this in turn by red sandstone and red shale. Below the last are alternations of white limestone with red shale, the limestone very soft and friable. All underneath this seems to be red shale.

Upon this same range occurs the South-dipping exposure, S. of Orwigsburg,—where, however, the hill is high,—with yellowish sandstone, externally pink, in fragments upon the surface, and no red shale to be seen. The latter probably lies lower in the series than this calcareous band.

3. The *Pre-Meridian and Meridian* series give no sufficient evidence of being present in this region. There is a massive conglomeritic sandstone W. of Friedensburg, upon the Southern

side of Long Run Ridge; also seen in Swope Hill south of the Swatara River Dam; but this is a Cadent rock, and not the Meridian sandstone.

The general character of the Cadent and Vergent rocks is such as to render them useless for building purposes; but some of the strata are sufficiently even and homogeneous to be so employed. A very hard grey sandstone, dipping 30° S., is got in slabs of two and three feet thickness from the top of the Schuylkill Mountain, and has been used in the abutments of a bridge near the tunnel.

A quarry has been opened much lower in the series on the Western side of Pine Creek, and yields a fine grey building-flag, easily detached, and from two to four inches thick, remarkably straight and smooth. It is near the end of the fifth anticlinal.

On the opposite side of this high ridge, looking into the gorge of the Little Schuylkill, diggings *for coal* have been made in the deceptive, soft, blue-black calcareous slates, which represent, no doubt, the Cadent lower black slate.

4. *The Ponent, Vespertine, Umbral, and Seral* rocks, overturned and dipping 30° S. 30° E., are admirably exposed in the gorges of the Second and Sharp Mountains made by the West Branch of the Schuylkill and the Main River, N. of Schuylkill Haven.

The Second Mountain rises about 900 feet above the river, and has a double crest, the Northern marking the outcrop of the Vespertine white sandstone, and overlooking the Umbral red shale valley of Rausch Creek and Mount Carbon; the Southern, composed of massive silicious Ponent strata, looking down upon the valley of Orwigsburg and Schuylkill Haven. The river makes a sharp double bend in the soft rocks, whose outcrop forms the channel between the summits. On the Southern flank are compact red shales and sandstones, and these alternate at the base and on the Northern slope of Little Mountain, with brown, grey, greenish, and buff sandstones.

Ponent rocks are again cut through where the Schuylkill traverses the synclinal trough near the old canal tunnel. The Section here presented will express all that is needful to characterise their appearance and structure.

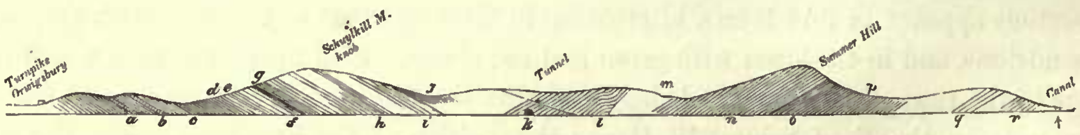
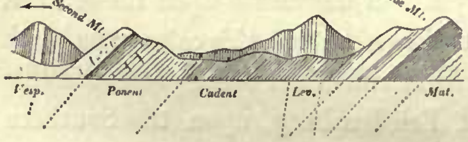


FIG. 40.—Section near the Schuylkill, through Summer Hill.

a, Surgent limestone and slate (30° S.), limestone blue; *c*, slates; *d*, 30° S., Cadent fossils in abundance; *e*, blue-grey sandstone; *g*, hard thin sandstone; *f*, Vergent grey and blue shale—hard grey slate above; *h*, *Ponent* red sandstone, 30° S.; *i*, grey sandstone; *j*, Ponent red shale on surface; *k*, compact Ponent red sandstone, 25° N., from opposite the tunnel on the canal Southward; *l*, little roll in grey sandstone, 45° N.; *m*, red shale at surface (alternation of Ponent and Vergent); *n*, regular thin-bedded hard green Vergent flags; *o*, Cadent shales and slates, 20°; *p*, Here is seen Cadent shale, blue, compact, crushed, 30° N., dip 60° S.—cleavage exposed 900 feet, underlaid by fossiliferous dark brittle shale; *q*, Surgent red shale and sandstone; *r*, red shale and sandstone, 15° N., 60° W., circling round the end of *second* anticlinal flexure, the axis of which ranges three-fourths of a mile to the S.

The following Section of the Blue and Second Mountains, and the valley between them, is introduced to show the varying contours of the surface, as this is influenced by the dips of the strata. It applies to the district between the Swatara and the Susquehanna.

FIG. 41.



CHAPTER VII.

FROM THE SWATARA TO THE SUSQUEHANNA.

West of the Swatara the form of the Fourth District under description is simpler, being that of three parallel mountains, the Blue, the Second, and the Third or Sharp Mountains, with two included valleys. These represent the single steep outcrops of more than one-half of the whole mass of the Palæozoic series of this part of Pennsylvania, that is, with the exception of the Pre-meridian and Meridian series, from the Matinal slates up to the Seral conglomerate and the Coal.

The dip of the Blue Mountain rocks S. of Pine Grove is 45° N. At the Swatara Gap all the series dip almost vertically, but Northwards: at Indian Gap, 70° N.; at Monody Gap all are overthrown, so as to dip 80°—85° S. Three miles further W. than the last is Hacket's Gap, a notch in the mountain, where a road crosses.

The Cadent sandstones at the base of the series (the yellow sandstones of the last Chapter, overlying the limestone), are interstratified with fine conglomerates towards the bottom, and being therefore a resisting mass in the middle of softer ones, forms a ridge upon the Northern flank of the Blue Mountain, so high as to command the range of Cadent shales that runs along the middle of the valley. At the Swatara Gap this lower sandstone forms a smaller mountain, called Swope Hill, parted from that of the Levant white sandstone by a ravine descending to the river. The same occurs at the Susquehanna Gap.

The Surgent red shale is about 500 feet upon the Susquehanna. No Surgent or Scalent limestone has been discovered at the river, nor indeed W. of the Swatara Gap.

At Hacket's (or Smith's) Gap, "nests" of good iron-ore occur in the lower part of the sandstone formation, overlying the proper place of the limestone, and perhaps corresponding to the iron ore before mentioned as obtained with the limestone in the Gap at the furnace S. of Schuylkill Haven.

An indistinct band of ore was observed in the Vergent flag formation, W. of Pine Grove.

The Ponent Red Sandstones cease in this part of the district to form a double-crested ridge with the Vespertine conglomerate. The latter forms the top of the mountain opposite the Cold Spring, while the red sandstone forms a terrace on the Southern side, not more than two-thirds the height of the mountain, and trenched by ravines, which do not affect the upper slope. The summit is a very level plain of sand, 300 feet in width. At the Swatara Gap, *above Pine Grove*, the dip is inverted, being 85° S. After receiving an anticlinal axis six miles further W., the Second Mountain sweeps round into proximity with the Blue Mountain; the dip becomes vertical, the mountain-tops being one mile and a half asunder. Further W. the dip falls off a little S., and of course the valley widens correspondingly. On approaching the Susquehanna, the valley grows narrow as before, because the dip becomes first vertical, then overturned.

BOOK IV.

FOURTH, OR NORTH-EASTERN DISTRICT.

The next great subdivision of Pennsylvania which presents itself for description is that portion of the N.E. counties which is bounded by the escarpment of the Pokono or Catskill Mountain on the S.E.; by the Delaware River on the N.E.; by the Lehigh, a part of the Susquehanna, and the table-lands of the bituminous coal-region, on the W.; and by the State of New York on the N. The S.E. division of this extensive, but rather monotonous district, is nearly separated from the rest by the deep and regular coal-basin of the Lackawanna, while the whole N. portion, again, is cut into two approximately equal parts by the deep transverse valley of the Susquehanna, flowing from the New York line to the boundary of the Lackawanna or Wyoming Coal-field. It thus consists of three natural subdivisions, the first being the plateau watered by the upper tributaries of the Lehigh and by the Lackawaxen; the second, the triangular area N. of the coal-basin and E. of the Susquehanna; and the third, the much-indented tract lying to the W. of that river. These several regions will be described in the order here sketched; but before entering into details, it will be expedient to introduce a general account of the formations in the special type which they exhibit within the district.

CHAPTER I.

STRATA INCLUDED IN THE NORTH-EASTERN DISTRICT.

The geological composition of this wide region of North-eastern Pennsylvania is less diversified than that of any district yet described. Excluding the coal region, and the formations which immediately adjoin it, namely, the Coal-measures, Seral conglomerate, and Umbral red shale; the only rocks appertaining to the district are the Vergent, Ponent, and Vespertine series.

VERGENT SERIES.

The lowest formations of the Palæozoic system, which reach the surface in the district we are now considering, are the Vergent flags (Portage group of New York), and the Vergent shales (the Chemung group of New York); the other inferior strata, the Cadent upper black slate, Cadent shales, and Cadent lower black slate, though well exposed and in full dimensions in the third district, between the Delaware and the escarpment of the Pokono Mountain, are nowhere here seen, not even along the N. border of the State, in Bradford County, where they might be looked for low in the valley of the Susquehanna, on the summits of one or other of the broad anticlinals. Layers of dark shale are occasionally met with near the river, some specimens of which, in a wet state, are nearly black, and these have, in several instances, led persons, ignorant of the geology of the State, to the erroneous impression that this region might contain a coal formation. They are, however, nothing more than argillaceous shales, a little darker than usual, of the Vergent series, four great formations too low for any productive coal.

VERGENT FLAGS.

This formation is seen chiefly on the North Branch of the Susquehanna, uplifted by the anticlinal waves of the strata, especially by that which crosses the river near the Wyalusing Falls, and by that of Towanda. It is the group of rocks which form some of the bolder river-cliffs of those neighbourhoods. The greater relative hardness of the layers, compared with those of the overlying formation, and their very regular and continuous bedding, give to these scenes the very same features which this mass, from similar causes, imparts to many of the more picturesque localities on the main Susquehanna, the Juniata, and the Potomac.

Thickness.—The entire thickness of the stratum is perhaps nowhere exposed, otherwise we should see the well-characterised Cadent newer black slates (Genesee slate of New York). Observation indicates the portion uplifted above the level of the Susquehanna to have a thickness of from 800 to 1000 feet. Of the total magnitude of the mass, an estimate may be formed from the measurements instituted elsewhere, and from the ascertained direction of its thinning off. Thus the thickness of the formation at Huntingdon is 1700 feet, and is probably at least 1500 feet in the Muncy Hills. On the Genesee River it amounts, according to the estimate of Mr James Hall,* to about 1000 feet. We shall not commit a great error if we assume it, from these data, at from 1200 to 1400 feet for the region of the North Branch of the Susquehanna in Bradford County.

Lithological Features.—The great body of the formation consists in this district, as elsewhere, in the same general belt to the S.W. of thin-bedded fine-grained grey silicious sandstones, alternating with much thinner seams of blue and greenish slate, or clay-slate, interposed between almost every two bands of the sandstone. In the higher portions of the stratum there prevails a larger amount of argillaceous material, and the regularly-bedded or flagstone character is somewhat less conspicuous. Some of the layers of the sandstone, especially high in the formation, are a foot or more in thickness, but the average size of the bands is from six down to two inches. Graduating lithologically, and to a considerable extent also by its fossils, into the overlying Vergent shales, it is impossible to define with precision their respective limits.

Several of the internal structural features of these rocks are curious, and deserve to be specified.

Ripple Marks.—These are well seen, as in every other district of the State, where this group is exposed, and abound in great number, and present themselves very prominently, especially on the surfaces of the more regular and thicker beds of sandstone. The shales seldom contain these interesting impressions. This exclusion of ripple from the shales has been noticed in New York

* See New York Geological Survey.

by Mr Hall, who suggests that these fine-grained materials were deposited in waters too deep to be acted upon by the surface-waves. To this conjecture I must object, on the ground that it is scarcely conceivable that the bed and shore of the sea could have oscillated so frequently and over such very extensive areas, and with such uniform energy, as would be requisite were this the real cause of the difference in question. That the waters were comparatively shallow, during the deposition of all these strata, would appear to be extremely probable, if for no other reason than the known habits of the animal and vegetable races to which the organic remains of the formation are most nearly allied; but I conceive it to be still an unsettled point in the history of the older marine strata, whether the presence of ripple-mark is in itself any proof of the agency of surface-waves. The view presented by Mr Babbage, that ripples may be engendered wherever a fluid stratum passes over a movable sediment with a certain velocity, no matter what the depth, seems quite as much in accordance with familiar phenomena, and may account for the occurrence of this structure in many strata, where the transmission of the wind created billows, though a very shallow covering of sea would appear to be altogether inadmissible as a cause.

The Diagonal Lamination, so very commonly met with in many of our Appalachian rocks, as in the Levant sandstones, and the Vespertine and Seral conglomerates, is of frequent occurrence in the sandstone layers of this formation. The surfaces of deposition are less uniformly in the direction of their dip than in many of our other strata. They evidently indicate that a strong, steady, and widely-diffused current or stratum of waters was the immediate formative agent in their production. This current must have been kept almost constantly replenished with fine sand, and still more comminuted clay, and one may conceive the innumerable alternations in the layers of sandstone and shale to have originated in some steadily acting cause, connected possibly with the seasons, or it may be with a long succession of very gentle earthquake pulsations, which produced an alternate diminution and reinforcement in the velocity of the marine current. In speculating on the possible modes of origin of the ancient sediments, we ought, I conceive, to keep steadily in view the probable existence at all epochs of general cosmical forces, more or less analogous in their nature with those which at the present day control the beautiful and harmonious movements of the fluids which encompass the globe. It is not to be doubted that the ancient oceans had their great systematic shore-currents and middle eddies like those of the modern Atlantic and Pacific Seas, and it is altogether possible that this circulation of the earth's waters, like its paroxysmal heavings, was more active in the earlier ages, when the climates were warmer, and the rains, as a consequence, more copious, and when the whole space overspread by the waters was unquestionably more extended than at the present day.

The *Organic Remains* peculiar to this formation are chiefly certain species of Fucoides. These occur in the inferior more argillaceous beds which outcrop in the State of New York, near the line between the great body of the flagstones and the Cadent upper black slate. Besides these are a few species of shells not seen in any other formation, with some that belong likewise to the black slate in Pennsylvania. Of the Fucoides proper to the flags, one variety, the *Fucoides graphica* of Hall, is very abundant on the surfaces of the sandstone layers. The form is that of a compressed, rigid, very elongated, oval stem, tapering to a blunt point at each end. In the higher part of the formation, some of the layers contain a vertical Fucoid, if it can be so termed, a simple stem-like form, crossing the plane of the bedding. This is evidently a species of *Scolithus*, and, except that it is a little less regularly cylindrical, resembles greatly the species so characteristic of the Primal sandstone.

VERGENT SHALES.

Those portions of the district before us, which lie in Bradford and Tioga counties, consist chiefly of the Vergent shales—the Shemung group of New York—capped in the higher localities, especially near the waters of the Wyalusing, by the lower beds of the Ponent series. In fact nearly the whole surface, represented on the Geological Map under the general tint for the Vergent series, is in this district covered by these shales. All the best agricultural lands of the two counties just mentioned rest upon these rocks, which being argillaceous, and containing a small share of carbonate of lime and a little of the oxide of iron, have produced, by their disintegration, a much more fertile soil than has been derived from the more Silicious, Ponent, and Vespertine stratum.

Thickness.—The Susquehanna Valley, especially between Tioga Point and the mouth of the Mahoopeny, offers a series of very fine outcrops of the different divisions of this enormously thick formation. Undulating in three grand anticlinal waves, each many miles in breadth, with everywhere a very small angle of dip, it is impossible to procure, in any one neighbourhood, a natural section exhibiting the entire mass of the formation. A compilation of measurements, made at various places, enables me, however, to infer that 2500 feet is about its true thickness between Towanda and Tunkhannock. This result implies a gradual reduction in the dimensions of the deposit in a N.W. direction, inasmuch as it measures 3150 feet in the vicinity of Catawissa. That this is the direction of its more rapid thinning, is demonstrable from the fact established by Mr James Hall, that on the Genesee River, still more to the N.W., in New York, the total thickness of the formation is no more than 1500 feet; whereas at Huntingdon, and on the Potomac in the S.W. direction, or parallel, as I conceive, with the ancient Appalachian shore, it has the magnitude of 3000 or more feet, as at Catawissa.

Lithological Features.—In its composition this deposit, as developed on the North Branch of the Susquehanna, differs but little from the type it holds at Catawissa. It is everywhere a mixture of sandy clay-shales and argillaceous sandstones, and the only material changes which it undergoes when traced from the S.E. outcrops to the N.W., are—first, a gradual augmentation in the proportion of the clayey element in all the layers; and, secondly, a yet more obvious alteration of texture, due, not to original composition, but to the metamorphic agency which has partially operated on all the S.E. belts of the State. In the third district, we everywhere observe the Cadent and Vergent strata much indurated and pervaded by cleavage-structure, and by countless fissures; but advancing N.W. to Susquehanna, Bradford, and Tioga counties, or across the table-lands of Pike, Monroe, Wayne, and Luzerne, we leave the belt of folded anticlinal flexures, and enter a region where the rocks have been much less disturbed, less fissured, and where they preserve more fully their original lamination, have a lighter colour and a softer texture, and are much more nearly in the condition in which they were precipitated as sediments on the oceanic floor. Along the N. border of the State, the formation consists of a vast succession of thin layers of shale of every hue, from a deep olive black and dark green, to a light slaty grey, in close alternation with thin beds of sandstone, the predominant tinge of which is brownish grey, but which, like the shale, has a variety of colours. Much of the sandstone is more or less green or olive, and, in the higher portions of the group, we meet with some reddish-brown sandstones, not distinguishable in aspect from the Ponent series. Some of the beds of shale, especially near the middle of the formation, are decidedly calcareous, and we even occasionally encounter layers of impure sandstone, replete with organic remains, particularly with bivalve shells. These calcareous strata are much more numerous and richer in lime in this N. belt than they are further S.E. in the formation, and there would appear to be an augmentation in the abundance of imbedded fossils in the group generally. Mica, in minute scales, is a common constituent in both the shales and sandstones, but most abounds in the latter, to many of the layers of which it imparts a fissile structure; high in the formation, some of the sandstones are very coarse, and there are layers which even merit the appellation of Conglomerates. These are seen capping the summits of some of the hills, a few miles W. of Tioga Point. They have been frequently confounded with the Seral or coal-supporting conglomerates by the inhabitants of the district, but they are altogether too low in the series of our rocks to indicate proximity to coal. The largest bed of conglomerate met with, namely, at Davis's excavations for coal, three miles W. of Tioga Point, is not more than a few feet in thickness. The pebbles, which are seldom larger than a pea, are chiefly of igneous quartz. They are more thoroughly water-worn and rounded than those of the Seral conglomerates, and they are imbedded in a coarse sandy material, derived apparently from several of the subjacent formations, but chiefly from the Vergent, to which this bed itself unquestionably belongs. That such is its real geological age, is manifest from the organic remains in the strata immediately above and below it. This stratum is probably the equivalent of a conglomerate which is met with in many places in the Third District—for example, in the vicinity of Pine Grove, Schuylkill County, and again in Bedford County, on the Raystown Branch of the Juniata. Its position is in the Vergent shales about one-third of the thickness of the formation from the top. It is perhaps the best building-material on the North Branch of the Susquehanna, having been selected by the architects for the abutments of the dam on the Pennsylvania Canal at Tioga Point.

Features of Deposition.—Among the more striking phenomena, indicative of the conditions of depositions of the Vergent rocks, are a profusion of ripple-marks, usually small, much slightly-inclined *diagonal lamination* in the sandstones, and numerous shrinkage-cracks upon some of the shales.

There are other structural features, such as the concretionary form, in some of the more calcareous shales which must have originated subsequently to the precipitation of the sediments. These concretions abound most in the lower numbers of the group, and along the North border of the State. Some of them approximte to true Septaria, being spheroidal, and intersected by seams of crystalline carbonate of lime.

Organic Remains.—A very great number of species are to be met with in the Vergent rocks of the Third District, and the comparatively unaltered condition of the slate permits the specimens to be extracted in a more entire and perfect state than they ever present in the disturbed region N.W. of the Kittatinny Valley. Among the most abundant forms are several species of Brachiopodous shells. Of these the genus *Strophomena* is represented by several very beautiful delicately-ribbed species. There are likewise several forms of the genus *Orthis*, and some finely characteristic large species of the genus *Delthyris* or *Spirifer*, and with these the *Delthyris mucronata*, so common likewise in the Cadent shales. Other genera of Mollusca are also well represented; thus there are several interesting forms of *Avicula*, among which are *A. Damnoniensis* of Europe. The genus *Pecten* has a number of representatives, and also the allied genus *Lima.* Of *Trilobites* there are but few to be met with, and these belong chiefly to the genus *Calymene.* Of vegetable fossils, the formation contains in the district before us, besides several Fucoides, some of them of the species seen in the Vergent flags, two or three highly interesting forms of land plants, being among the very earliest vestiges of *terrestrial vegetation* hitherto discovered, either in our Appalachian rocks, or in the equivalent Palæozoic strata of any portion of the globe. One of these is a fern of the genus *Sphenopteris;* others belong to the genus *Lepidodendron,* and are allied to fossils of the Carboniferous or coal era. These may occasionally be found in Bradford and Tioga, but are not restricted to this district, since they occur further towards the S.E. and S.W.

PONENT SERIES.

No one of the great Appalachian deposits is so completely exhibited in the district we are considering as the Ponent series; indeed, this region is particularly characterised by it, and is the only tract within the limits of the State where the whole group is developed under all its modifications of type. The wide expansion of the district in a N.W. direction, gives us a view of the whole of the series, from its maximum developments on the S.E., in the escarpment of the Pokono or Catskill Mountain, through all its changes of magnitude and composition, until it thins entirely out in the North-western part of McKean County. A full study of the stratum is greatly facilitated by the topographical structure of the district. Wide, gentle, anticlinal waves spread it largely over the surface, in all the table-lands of the Lehigh and Lackawaxen, lifting it through the Vespertine sandstones in the N. parts of Wayne and Susquehanna, and S. part of Bradford, making it the uppermost rock, and in the synclinal plateau of Bradford and Tioga, where its thickness is much reduced, protruding the Vergent strata through it, and thus giving it an outcrop at the base of each of the coal-sustaining escarpments. All along the South-east border of the district, this formation itself constitutes almost the entire pile of the Pokono and Catskill escarpment, from the base to nearly the summit of that grand mountain-wall. On the N.E., the whole elevated table-land is intersected by the deep transverse valley of the Delaware River, which discloses a superb general section of this stratum, through a distance of nearly sixty miles. Even in the region of the Lehigh and Lackawaxen, where the higher summit of the plateau is overspread with the Vespertine conglomerate, the valleys of these and their tributary streams are excavated in the Ponent series, and furnish us with clear and extensive natural sections.

Lithological Composition and Thickness.—Notwithstanding the full exhibition which this region offers of the Ponent strata, it is, except in its organic remains, destitute of much interest to either the scientific or practical inquirer; even its fossils are comparatively few, if we consider the great bulk of the deposit.

In the region of its greatest development, that is to say, in the table-land of the Lehigh and Wallenpaupack, the whole group, still retaining in a great degree the coarse type which it exhibits in the S.E. escarpment of the plateau, as described in Book III., is composed of a vast succession of thin-bedded argillaceous red and grey sandstones, more or less micaceous, with thin interposed seams of red, green, and mottled shales; also coarse and fine sandstones, of various hues of red, brown, grey, and greenish and mottled red and green, together with red, grey, and greenish coarse silicious conglomerates. Many of the silicious sandstones, and nearly all the conglomerates, are thick-bedded, and possess the obliquely-laminated structure in a very conspicuous degree. The coarse grits with pebbles occupy the upper part of the mass, and mark the passage between this formation and the overlying Vespertine conglomerate; the red and grey sandstones constitute the great bulk of the whole series, the shales predominating in the middle and lower portions especially. This is the character of the mass in its South-eastern type, where it has its maximum thickness. It has been already described as at least 4500 feet thick in the escarpment, and at the foot of the Pokono; but it appears to thin at a steady and rather rapid rate North-westward, so that near the sources of the Lehigh and the Wallenpaupack it probably does not measure more than 3500 feet, and around the Wyoming coal-basin not more than 2500 feet. Ascending the Delaware to the North corner of the State, or advancing up the Susquehanna to the Tunkhannock, or Alleghany Mountain escarpment, we find its dimensions not to exceed 1500 feet. In this last-mentioned belt the formation holds a middle type between its South-eastern and North-western ones. It no longer contains any very coarse grits, and the sandstones are all finer grained and more argillaceous; while the proportion of red and green shale has obviously augmented. One or two calcareous layers appear near the centre of the group, which are not seen far to the S.E. These beds acquire more carbonate of lime in their progress North-westward, but they are nowhere sufficiently calcareous to be of utility for the manufacture of lime.

Tracing the formation yet farther towards the N.W., or rather towards the W., its thickness continues rapidly to decline. Thus it was measured in the escarpments on the Loyalsock, and showed a thickness in that region of about 1000 feet. In the S.E. flank of the Armenia Mountain, near the crossing of the Williamsport and Elmira Road, its total bulk is reduced to about 400 feet. Near Wellsborough, in the Southern flank of the fourth spur of the great table-land of the coal rocks, the whole Ponent series has scarcely the dimensions of 100 feet; and in the North-western side of this basin, and in the fifth spur near the Comanesque, we find it extremely thin. It is traceable, however, through Potter, M^cKean, and Warren counties nearly to Warren, where it finally vanishes.

Organic Remains.—The fossils hitherto discovered in the Ponent rocks of this and the fifth and sixth districts, are, as respects the number of species, very few; but some of them are of peculiar interest. Several forms of carboniferous terrestrial plants are frequently found, particularly in the upper strata. These are species of *Sigillaria, Lepidodendron,* &c.; only a very small list of shells is known, belonging chiefly to the genus *Cypricardites* and allied forms. But the fossils which more particularly distinguish the formation are the relics of certain very peculiar fishes, of a type especially characteristic of the Old red sandstone, or Devonian strata of Europe. One of the most curious of these is the *Holoptychius nobilissimus*, a beautiful species, first discovered in Great Britain, but also found in the Ponent strata near Blossburg, and described by Professor James Hall. Another is the *Sauripteris Taylori*, from the same locality.

No seams of coal have ever been found in the Ponent strata, and it would therefore appear that the true carboniferous vegetation, the dawn of which began, as we have seen, in the preceding Vergent period, was not even yet sufficiently abundant to clothe the surface anywhere with continuous carbonaceous matter. It is probable, also, that the earth's crust was too much disturbed at this era to permit the requisite accumulation of vegetable matter upon a succession of nearly stationary level floors, such as appear to have supported the coal forests and morasses. Of ripple marks and planes of diagonal lamination, this formation offers innumerable instances.

Vespertine Conglomerate.—The uppermost formation of any part of the district before us, if we except the borders of the Lehigh, opposite the ends of the coal-basins, where the Vespertine red strata lies in the synclinal troughs, is the Vespertine conglomerate. This great arenaceous stratum occupies all the higher parts of the South-eastern table-land, as the knobs of the Pokono or Catskill; and it encircles the Wyoming, or Lackawanna Coal Valley, with a massive mountain-girdle rising outside of and high above the outcrop of the Seral conglomerate and Umbral red shale. It is more uniformly spread over the South-western half of the plateau, or that watered by the Lehigh, than over the North-eastern, drained by the Wallenpaupack and Lackawaxen, where the Ponent rocks cover a larger extent of surface than they do around the Lehigh. This is in consequence of the general deepening of all the synclinal troughs towards the anthracite coal region, or in the South-western direction. The only other part of the district which is covered by the Vespertine rocks, is the belt of hills or mountain summits bordering the valley of the Tunkhannock Creek, being the prolongation across the Susquehanna of the first synclinal plateau or spur of the bituminous coal region.

Lithological Composition and Thickness.—This formation, interesting, as being the lowest or earliest of the true carboniferous deposits of the Appalachian system of strata, is of very extensive distribution along the whole Appalachian Chain, and beneath all its coal-fields. By its composition and organic contents, it clearly denotes the first great stage in that mighty train of causes which conspired to produce the coal strata. Of shore or terrestrial derivation, it is essentially a coast and shallow-sea accumulation, and has necessarily, with a great extension S.W., or coast-wise as to the ancient carboniferous sea, a more restricted expansion in the direction Westwards, or towards the deeper ancient waters. We thus behold it in its maximum thickness, coarsest texture, and most miscellaneous composition in its Eastern outcrops, and can trace it to the N.W., gradually altering its type to that of a more strictly aqueous deposit of fine sediments. In its most developed form, as it presents itself in the Southern corner of the district, between the Pokono Knob and the Lehigh, this rock has almost precisely the composition which it wears in the Mahoning, or Second Mountain, bordering the Southern Coal-field, being a succession of coarse silicious conglomerates, grey, white, and yellowish grits, and dark blue and olive-coloured shales, with an occasional bed of black carbonaceous slate. It contains numerous impressions of fragments of coal vegetation, especially stems of *Lepidodendron* and *Sigillaria*, and very rarely an extremely thin, imperfectly formed, and very local seam of soft impure coal. In the mountains which enclose the Southern Coal-basin, its thickness near the main Susquehanna River exceeds 2000 feet, but it is less expanded near the Lehigh, measuring in the vicinity of Mauch Chunk about 1300 feet; even this latter measurement expresses much more than its actual thickness in the county E. of the Lehigh, where an extensive denuding action has carried off from the surface of the table-land all the higher strata of the formation. As we recede Eastward from the Lehigh, the capping of the Vespertine rocks becomes thinner and more interrupted, until, in the region of the Lackawanna and Delaware, they are restricted to the insulated knobs which rise at intervals from the surface of the Catskill plateau. In the Wyoming or Moosic Mountain, the South-eastern barrier of the Wilkesbarre Coal-basin, no general section discloses its whole thickness, except in the Western part of the range, where the inferior rocks reach the surface in the anticlinal of the Wapwallopen. There, and in the Catawissa, or Nescopeck Mountain, also a prolongation Westward from the district we are reviewing, the entire stratum measures as much as 1100 feet. It cannot be materially less in the Capous or Lackawanna Mountain on the N.W. side of the Coal-basin. Advancing a step further to the next and last synclinal, which contains the formation, namely, that of the Tunkhannock Mountain, we there find only the lower members of the mass, the elevation and shallowness of this trough having exposed the upper and middle portions to extensive removal by the denuding floods. It will be seen by a reference to the Geological Map that this belt gradually tapers to a point as it passes towards the sources of the Tunkhannock Creek, near the Loyalsock, where the entire formation is preserved by a thin capping of the true coal strata; its total thickness is about 900 feet, but E. of the Susquehanna it probably nowhere retains more than one-third, or one-half of that magnitude.

In the belt here spoken of the rock possesses very little of the conglomeritic character so distinctive of one portion of it in the Pokono summits. It has passed to the form of a grey, somewhat argillaceous and micaceous flaggy sandstone or grit, abounding in oblique lamination, and still retaining a structure strongly indicative of an origin from paroxysmal currents directed North-westward—such as we must appeal to, as having strewed the grits of the next great arenaceous and shore deposits, the Seral conglomerate, and Coal series.

For a knowledge of the further progressive changes of thickness and composition which the formation undergoes in its range along the Western border of the district, the reader is referred to Book IX. Division I., where the Vespertine rocks of the bituminous coal-fields are systematically described.

Organic Remains.—Within the limits of the district now before us, the Vespertine conglomerate and sandstone do not seem to contain any animal remains of either shells or fishes; but further towards the N.W. a few fossils are to be met with, there being a calcareous layer, low in the formation, imbedding more than one species of *Delthyris*, &c. This general absence of marine relics from the rock, in its coarse, south-eastern type, is just what we should anticipate upon a view of the origin of all that portion of the deposit. It is pretty evident from an inspection of the strata, that the surface was too imperfectly submerged, and too frequently deluged by violent but shallow oceanic waters, to be the abode of marine mollusca, or other races.

In the chapters on the Palæontology of the State, I shall show that the fossil plants of this formation, while they belong to the genera ordinarily characteristic of the carboniferous deposits of our own country, and of Europe, are specifically distinct from those of our true coal strata or Seral group.

CHAPTER II.

STRUCTURE AND LOCAL DETAILS OF THE SOUTH-EASTERN DIVISION OF THE DISTRICT.

By glancing at the Geological Map, it will be seen that the table-land South-east of the Wyoming Coal-basin has its South-eastern escarpment broken by two spurs running Eastward towards the Valley of the Delaware. Each of these mountain promontories denotes, as this feature of our table-land topography invariably does, a regular synclinal trough or basin in the strata, the offset or indentation in the mountain behind, or N. of each spur, marking the position of an important anticlinal wave or axis.

The more Southern of these knobs, called the Big Creek or Kettle Mountain, is simply the second or outer mountain-barrier of the Southern Coal-basin. It consists of the Vespertine conglomerate, doubled round its Eastern end, the anticlinal elevation of the strata prolonged from the third district passing behind the knob, and across the Lehigh into the Nesquihoning or Broad Mountain, the Northern side of the trough or basin called the Kettle, while the Southern side is elevated by an anticlinal which crosses the Lehigh near Lehighton. The other, styled in the maps the Pokono Knob, is a broader synclinal spur, having less of the basin form, the anticlinal on its Northern side being less arched, and the S. dip of the North side of the trough being therefore gentler. This second synclinal is but the extension Eastward of the basin of the Beaver Meadow Coal-field; and it is extremely probable, that the broad anticlinal indentation to the N. of it expresses on the topography the several closely-packed but flat and feeble axes which divide the small Lehigh coal-basins. The undulations in the Vespertine strata on the Lehigh opposite the ends of these basins, and directly in a line with this great recess in the escarpment of the Pokono, seem strongly to confirm this view. A consideration of these structural features makes it apparent that the whole South-eastern corner of the district, or that between the escarpment and the upper reach of the Lehigh, is overspread by the Vespertine sandstones undulating in wide and gentle anticlinal and synclinal waves.

The structure of all that part of the table-land which is embraced between the Lehigh and the margin of the Wyoming Coal-field is extremely simple, the whole belt being nothing more than a broad and flat anticlinal arch or wave in the Vespertine sandstones, having a very gentle South-eastern dip towards the Lehigh, spreading horizontally over the axis in the middle part, and descending with a steeper North-western inclination toward the Coal-basin.

It is, in truth, only the Eastern end of the long and beautifully regular anticlinal of Montour's Ridge here sinking and flattening away in the Vespertine plateau.

In the region of the Wallenpaupack and Lackawaxen we no longer recognise any of the undulations of which mention has just been made. Another series of anticlinals, unconnected with those of the country between the Lehigh and the main Susquehanna, control the dip and distribution of the strata. These axes are, however, feeble, and exert but little influence; they are the North-western expiring waves of the group which includes the interesting regular normal anticlinals of the Appalachian Valley of New Jersey and Orange County, New York.

The fine natural section of the rocks on the Delaware exhibits these North-western waves prolonged from the table-land of the Catskill Mountain of New York into Pennsylvania.

It has been already stated that the chief part of this region, drained by the Lackawaxen and other tributaries of the Delaware, is overspread by the Ponent series. These occupy a general synclinal basin, and are in many places capped, especially in the loftier eminences, by the inferior beds of the Vespertine sandstone. (Section I. gives the general structure of the region.)

Local Details.—On the dividing ridge between the Sawkill and the Shehola occur the lower beds of the Vespertine conglomerate. In many places the surface is covered with sand, pebbles, and small boulders referable to the great stratum of drift which, though much reduced in thickness in this latitude, is yet distinctly visible.

In the Valley of Shehola, near the Falls, we meet the Ponent series, recognisable by the red soil and fragments even where the strata are not seen.

At Darling's, one mile and a half N.W. from Shehola Falls, occurs a calcareous conglomerate, in a thin layer nearly encircling a small meadow. It is nowhere more than two feet thick, and consists of concretions of impure limestone in an argillaceous sandstone, and seems to be identical with the layer of similar composition visible in the lower part of the Vespertine rocks in many other districts.

Between the Shehola and the Lackawaxen at Mount Moriat, the country is much overspread with a grey and greenish thinly-laminated micaceous sandstone, which, after dipping very gently North-westward over a wide belt, becomes nearly horizontal as we approach the Lackawaxen. These strata constitute the inferior portions of the Vespertine conglomerate formations.

From Mount Moriat, ascending the Lackawaxen and thence the Wallenpaupack, we pass over much of the red sandstone and red shale of the Ponent series. At Wilsonville a little oxide of manganese was found in the crevices of the strata in an excavation made for draining some marshy flats.

In the flats at Tafton there is a thin deposit of bog iron ore nowhere more than 18 inches thick. Between Mount Moriat and Honesdale and Bethany, the country is much overspread in all the more elevated tracts by the horizontal strata of grey and greenish-grey Vespertine sandstone. About four miles S.E. of Honesdale the Ponent red sandstone and red shale become more abundant, lifted by an anticlinal. Here the summits of the hills are still frequently capped with the grey Vespertine rocks. In this neighbourhood we meet with the margin of a more fertile country. In all the table-land to the S.E., wherever the Vespertine rocks occupy the surface, the soil is too sterile to repay the toil of cultivation, and therefore three-fourths of this portion of Pike County remains in the condition of a wilderness, being clothed with a nearly unbroken forest of scrub-oak and dwarf pitch-pine. But entering the more genial Northern belt, we recognise the influence of the Ponent rocks; a deep thick forest of hemlock and beech takes the place of the other, and with a friendlier soil, occur a much larger amount of cultivation and a less sparse population.

In the vicinity of Bethany the grey sandstone is less frequent than the red. An impure calcareous rock, one of the beds of the Ponent series, or more probably the limestone so commonly met with in the lower part of the Vespertine formation throughout parts of Bradford and Tioga, lies in large loose masses about the hills and low grounds four miles E. of Honesdale. It has a very rough exterior from unequal solution of its different constituents, and being very dark, the round weathered masses are familiarly called *Negro-heads*, or, more vulgarly, *Nigger-heads*.

In the neighbourhood of Bethany are ponds affording a very pure sand, suitable for the manufacture of glass, which has been pursued to some extent at that place.

The red Ponent shales and sandstones extend from below Honesdale north-eastward towards the Great Eddy on the Delaware, but are not visible along the river shore for a few miles above the Eddy, the hills there being of the Vespertine green and grey sandstone common to the region on the S. A little above Damascus, however, we find the red shale; and it may be seen on the turnpike a mile from the river. Pursuing this turnpike Westward, the red shale or sandstone alternates with a greenish sandstone for the distance of 15 miles, the red predominating. Fragments of the calcareous rock are frequent; and in one instance it was seen in place lying between the Ponent red sandstone and the grey Vespertine group. It was also found in place on the Easton and Belmont Turnpike, three miles below Clarksville, between the red and grey rocks.

The Moosic Mountain consists of the Vespertine strata, dipping at a low angle North-westward, and between its Southern slope and Bethany the chief formation exposed is the Ponent red sandstone.

In the vicinity of Belmont the Ponent rocks predominate. The Vespertine belts enclosing the coal-field terminate S.E. of Belmont in a succession of summits, and about five miles S.W. of the village is the Northern termination of the Seral conglomerate, the immediate floor of the coal strata. The true coal-measures are not met with, however, until we advance further Southward down the valley.

CHAPTER III.

STRUCTURE AND LOCAL DETAILS OF THE NORTH-EASTERN DIVISION OF THE FOURTH DISTRICT.

The Geological Map, and Sections I. and II. of the general series, will show the reader the general structure of the North-eastern division of the district embraced between the Delaware and Susquehanna rivers, and lying N. of the Lackawanna Coal Valley. He will notice that the great anticlinal belt formed of the several closely adjacent axes passing through the mountain-spurs of Union County, and prolonged in the wider valley between the Shickshinny and Alleghany Ridges becomes by the gradual subsidence of the lesser waves, and the sinking of the whole line of uplift, a broad and simple arching of the Ponent and Vespertine rocks in the region North-west of the Wyoming Basin. In the deep valley of the Susquehanna the denudation has exposed the upper Vergent strata in the central or crowning part of this grand anticlinal, but in the high country N.E. of the river, the Ponent rocks unite across the arch, and the Vergent are no longer visible. Still further toward the N.E., approaching the vicinity of Belmont, the Vespertine grey sandstones close over the axis, but at first, and for many miles, only in a detached manner, by the approximation of the outlying hills of the Lackawanna and Tunkhannock Ridges.

Even as far to the N.E. as this neighbourhood, the Ponent rocks are held up along the Anticlinal to the level of all the lower plains and valleys. Between Belmont and the Delaware the Vespertine grey sandstones overspread the greater part of the surface.

To the N.W. of the anticlinal belt just referred to, is the synclinal range of mountain-knobs and broken hills, along which flows the Tunkhannock Creek. This belt is but a continuation of the S.E. table-land, or basin of the bituminous coal region, and is composed of the Vespertine strata, gradually diminishing in breadth and thickness.

Of the Vespertine Mass as it extends North-westward.—The belt of country next N.W. of the Tunkhannock Hills is of anticlinal structure, a broad low arch passing through it across the Meshopen and its tributaries, and crossing the Susquehanna, to prolong itself between the first and second table-lands of the bituminous coal region. In this tract the Ponent rocks occupy the higher grounds, but the whole series is thin, and the valleys disclose the upper members of the Vergent series. To this zone of country succeeds a rather more elevated synclinal belt drained by the Wyalusing. It extends North-eastward past Montrose. It is a prolongation of the second great trough or table-land of the bituminous coal region, and embraces, especially in the portion adjacent to the river, the lower strata of the Vespertine grey sandstones in a horizontal position. These rocks cap the more elevated tracts even in the vicinity of Montrose, the red Ponent rocks appearing in the beds of many of the deeper valleys.

Beyond the Wyalusing the Towanda anticlinal lifts the Vergent rocks to the general surface of the country, except in the very highest levels, where we find detached outlying patches of the thin Ponent series. This anticlinal passes four or five miles N. of Montrose, and is discernible at the great bend of the Susquehanna. Silver Lake is on its very gentle Northern dip. This zone of country constitutes nearly the Northern limit of the Ponent and Vespertine formations.

The region drained by Wysox Creek is a synclinal one, the extension of the trough, in which lies the third bituminous coal-basin. It is chiefly overspread with Vergent strata, easily distinguishable by their numerous fossils ; but some of the higher hills in the central portion of the tract contain the red strata of the Ponent series.

To this synclinal there succeeds a gentle anticlinal undulation in the Vergent rocks, the axis of which crosses the Susquehanna below Tioga Point, and extends to the Southern tributaries of the Weposening.

Thus, as the sections show, the N.E. division of the district consists of the three formations, the Vespertine Grey Sandstone, Ponent Red Sandstone, and Vergent Shales, distributed in obedience to four wide but very flat anticlinal waves, and three intervening synclinal troughs. A knowledge of the position and direction of these undulations, and of the strata belonging to each belt, will be readily acquired by a careful inspection of the Geological Map and Sections in connection with the above brief description.

LOCAL DETAILS.

Between Belmont and Stockport, which is seventeen miles N.E. of it on the Delaware, there is a wild rough region almost destitute of inhabitants for several miles from the river, and mostly covered with a forest of beech and hemlock trees. Nothing occurs to relieve the dreary monotony of the scene, but many beautiful and clear little lakes, sleeping calmly amid the sombre forest, and spreading their surfaces like mirrors in the bright sunlight. The rocks are the Vespertine green and grey sandstones, with belts of Ponent red sandstone, and as we approach the river the red becomes more frequent. The calcareous rock at the bottom of the first-named group frequently shows itself in loose masses, and near Stockport is clearly exhibited *in situ,* lying between sandstone strata in the bed of a deep ravine half a mile from the river, at an elevation of about 150 feet above the level of the Delaware. Thin seams of a dark-coloured slate appear sometimes between the strata in the cliffs along the river, which present long level beds of the thinly-splitting sandstone common to this country, alternating with red shales and sandstones. Limestone would be very serviceable in this region, but no indications of it appear, except the calcareous mixed rock, already so often mentioned, and which seldom or never contains lime enough to make it useful for calcining.

If we now pass Northward from Belmont, we shall find the Ponent red shales and sandstones predominating, though covered with the Vespertine green and grey rocks in many places as far as the head-waters of Starucca Creek, where the horizontal position of the strata seems to change to a slight Southern inclination, and the red shale ceases to be observed, the underlying Vergent shales coming to the surface. Beginning to descend towards the Susquehanna at Harmony, we find by the fossils in the strata near the river that we are upon this formation. Proceeding from Belmont North-westward across the Valley of the Lackawanna, we see in the hill on the East of the stream the Ponent red shales and Vespertine grey sandstones on the summit, without much inclination or dip. The silicious Seral conglomerate is not seen. This rock terminates at the point of the coal-basin four or five miles to the South. On the hill west of the valley little or no red shale is visible. Almost level strata of Vespertine flaggy grey sandstone occupy the hills nearly the whole way to Montrose. Belts of the underlying red sandstone do, it is true, sometimes appear.

In a mineralogical point of view, the three formations which overspread this North-eastern district of the State are remarkably destitute of interest, however instructive as respects their organic remains. Some very unimportant indications of copper have been observed in the Ponent red shales, but there is no evidence of veins or beds of copper ore of any magnitude or value. It is said that the ferruginous sulphuret of copper has been found near the village of Brooklyn, seven miles South-east of Montrose.

Both the Ponent and Vespertine sandstones contain in this region, as elsewhere, feeble springs of salt water ; the amount of salt in solution is in every known instance too small to give any economical value to the water. A few artesian borings have been made, but in every case without procuring a brine of the desirable strength. One of these, made many years ago, is on a branch of the Wyalusing Creek. It is stated by a person in the neighbourhood that his well was 500 feet deep, and yielded a full stream of weak salt-water, from which a little salt was made. Salt water has been found on Snake Creek, about eight miles from Montrose, but not of a quality to prove valuable.

CHAPTER IV.

STRUCTURE AND LOCAL DETAILS OF THE WESTERN DIVISION OF THE FOURTH DISTRICT.

THE Western Division of the Fourth District, or that embraced between the North Branch of the Susquehanna and the table-lands of the bituminous coal region, consists of four anticlinal valleys penetrating Westward between the spurs or basins of that plateau, the three more Northern ones opening out Eastward into a general plain E. of the extremities of the third and fourth coal-basins. The first or most South-eastern of these anticlinal valleys is insulated from the rest by the table-land of the mountain-basin of Towanda, and the belt of hills in its prolongation E. of the Susquehanna. Opposite the ends of the third and fourth plateaus of the coal, namely, the Blossburg and the Crooked Creek ranges, the strata of the Northern plain of Bradford County have of course the synclinal structure.

Topography.—A clear conception of the structure and stratification of this singularly constructed but very symmetrical region, will readily be attained by consulting the Geological Map and Sections, and by adverting to the following considerations :—

All the mountains or table-lands are *synclinal*, being the flat denuded basins projecting forward from the general coal region.

These synclinal table-lands are capped for the most part by the Vespertine sandstone, which forms all the higher portion of their escarpments. The Ponent red rocks outstretch near their base, and in the middle of each synclinal are thin and very circumscribed patches of the Seral conglomerate and Coal-measures.

All the valleys between these mountain-basins are of *anticlinal* structure, and owe their excavation to the greater power which the erosive currents had in removing the materials from the uplifted, exposed, and fissured anticlinal belts.

These anticlinal belts are, without exception, occupied by the higher Vergent strata, and towards their Western terminations by the overlapping Ponent rocks.

As the anticlinals slowly rise towards the E., the strata in the basins also rise in that direction, and thus the Ponent and Vespertine rocks forming the synclinal mountains become thinner and thinner by denudation, until they terminate, and the plateaus cease.

As each successive mountain-basin is shallower going North, and the Vespertine rocks are also thinner, the currents have had more denuding power over these than over those further South, so that each Northern plateau capped by these rocks is shorter and more broken than the one next South of it.

The anticlinal or valley belts, composed for the most part of the Vergent rocks, have an undulating hilly surface, strongly indicating the eddying action of great diluvial currents poured Southward across the mountain plateaus upon the more destructible, softer strata of these tracts. In their central portions over their anticlinal axes, the surface is usually more elevated and hilly than near the sides.

ANTICLINAL AXES.—*Axis No.* 1, *dividing the First and Second Basins.*—This crosses Lycoming

Creek one mile above the mouth of Pleasant Stream, and ranges thence in an almost perfectly straight course through the middle of the valley to the North Branch of the Susquehanna, which it crosses near the Wyalusing Falls.

Axis No. 2, entering the valley from the table-land of the Coal region, preserves a course about three miles to the N. of Roaring Creek, and the main upper stream of Lycoming Creek; there taking a gentle flexure Northward, and again more Eastward, it follows for some miles the valley of Towanda Creek, from which it gradually recedes Northward to maintain a nearly direct line toward the bend of the Susquehanna at the mouth of Wysox Creek.

Axis No. 3 pursues a very nearly straight course, or, like the others, one very slightly convex, towards the N. from the Round Islands or Pine Creek, where the anticlinal valley begins, to the mouth of Canal Camp Creek or Tioga River. This arch being broad and flat, the axis or central line is not traceable far to the Eastward with any great exactness. It crosses Sugar Creek about seven miles N. of Troy, and the Susquehanna River near Tioga Point, or between two or three miles S. of Athens. It probably curves between the Tioga River and Sugar Creek, very much like the second axis, opposite to it.

Axis No. 4, the precise line of which is not very readily followed in the strata owing to the gentleness of the arch, ranges along the Northern side of the Vergent belt from the sources of Pine Creek, keeping three or four miles to the S. of the Cowanesque Stream, until it meets and crosses it near the Western line of Lawrence Township, and leaves the State near Lawrenceville.

The curvature in the course of the second axis, and a local diminution in its height, and the steepness of its S. dip, will account for the widening Eastward of the second or Towanda table-land or basin.

It is a curious *law* of these anticlinals, violated in very few localities, that the Southerly dips are *steeper* than the Northerly. This structure of the region is remarkable as being the reverse of the far more comprehensive or almost universal law, applicable to the entire Appalachian Chain, of a greater steepness or degree of incurvation of the N.W. compared with the S.E. legs of the anticlinal arches. The fact in exception to this law is strikingly exhibited in an axis not included in our enumeration, which ranges along the valley of the Loyalsock and partially subdivides the first or Southern bituminous coal-basin. Sections No. IV. and No. VI. will make this feature apparent. The Southern dip of the Axis No. 2 is on the head-waters of the Lycoming Creek. Its S. dip is 25°, and its N. dip not more than 5°; and further Eastward the S. dip augments to 35°, and even 45°.

Near the mouth of the Towanda the S. dip is 10°, and the N. dip scarcely 4°. The same relation of the dips is noticeable along *Axis No.* 3, where the S. dip exceeds the N. by 2° or 3°.

This inversion in the relation of the dips of these anticlinals would be less remarkable if we had any proof that these waves in the crust flowed from the N.W. towards the S.E., but observations which I have made in New York, in the region N.W. of these flexures, have convinced me that the anticlinals there are but the still feebler pulsations of the same system or group, and that in this as in every other division of the great Appalachian Chain, without exception, these majestic billows in the strata have originated far to the S.E., and have passed North-westward. A positive demonstration of this view is afforded by the fact, that the Southern anticlinals of the group before us, notwithstanding their abnormal character, are bolder flexures than the Northern, and display the usual declension of height in the N.W. direction. What then can be the cause of so singular an anomaly? I am inclined to conjecture that it is due to a partial or imperfect coalition of two successive sets of undulations, the second series of billows finding the crust already arched into low anticlinals by a preceding group. The latter might readily press forward the synclinal troughs or downward bulging portions North-westward, and thus steepen the Southern dips more than the Northern. Some confirmation of this view is derived from the Serpentine curves which the Loyalsock and First and Second Anticlinals all exhibit at about the same part of their course. Perhaps the explanation is to be sought in the conception of a rebound of the billowy undulations of the crust as the flattening waves encountered the *vis inertia* of the undisturbed district beyond them.

LOCAL DETAILS.

Second Anticlinal Belt, or Towanda Creek Valley.—This beautiful valley has a soil derived from the Ponent red shale, and is bounded on the South by the regular high ridge of the coal mountain 900 feet high, up the flank of which the Ponent formation rises 300 feet. This bench at the top of the Ponent stratum is readily perceivable along the mountain.

On the North are the ascending hills of the Vergent strata over the second axis. These rocks rise from the very water's edge, in many places composing the whole of the hills; in a few instances they are capped by the Ponent mass, which always shows itself when present by a peculiarly steep and regular bench near the summit.

It will therefore be seen that this stratum cannot be so thick as on the Loyalsock, where it measures nearly 1000 feet. A good opportunity for estimating this was afforded by the Ponent Hills, forming the South-east flank of the Armenia Mountain. Over these hills the Williamsport and Elmira road passes two miles above Canton Corners.

The Vespertine sandstone caps the escarpment in a thickness of about 50 feet, but all the rest of the slope exhibits the outcrop of the Ponent rocks. At the base of the hill we find the top of the Vergent series. The Ponent group has a thickness of about 400 feet in this neighbourhood.

Limestone and Iron Ore in the Vergent Series.—In the eastern part of this tract of country, there are two bands of limestone in the Vergent strata, one 50 feet from the top, and quite thin; the other about 150 feet below the first. This latter is exposed along the North Branch of the Susquehanna in many places, particularly on the North dips of the first axis. It there attains a thickness of 10 or 15 feet, and is traceable for several miles. It yields good lime.

These bands are everywhere very fossiliferous; they are quarried at Monroe Corners; on the Towanda Creek; at the mouth of Carbon Creek, where one band is 4 feet thick; and at the head of Lycoming Creek, seven miles from Canton Corners, where the limestone is 4 or 5 inches thick, and has a covering of a very fossiliferous sandstone. The rock appears again on Tioga River, and at Wellsborough, at which latter place there are many strata of it, full of fossils for 50 feet up the hill at the back of the Court-house.

In fact, this seam, or rather these seams of limestone, are easily recognisable wherever 200 feet of the upper Vergent shales are exposed; when the rock is pure it is of importance for the lime it produces, but that is rarely the case. It is of greater importance as a guide to a stratum of iron ore, which holds nearly the same position in the series. Although the ore and limestone have rarely been found together, the ore is often accompanied by shales filled with fossils, similar to those filling the limestone. The place of this ore is about 200 feet from the top of the formation; its position is marked by a band of red shales and slates, and sometimes of sandstone, also by the limestone, which has a thickness varying from 5 to 30 feet. The ore will be described when the strata of the Tioga River are noticed.

Iron Ore on Schrœder's Branch of Towanda Creek, two miles S. of Canton Corners.—This ore occurs unquestionably in the Vergent or Chemung rocks. There are two beds, as follows:—

1. Calcareous shales, approaching the character of limestone, full of Vergent fossils, . .	10 feet.
2. Upper bed of ore, red and fossiliferous, ...	2 „
3. Greenish flaggy shale and slate, containing fossils, ...	8 „
4. Lower bed of ore, or red ferruginous fossiliferous sandstone, like that of Montour Ridge, .	3 „

These rocks all dip gently to the Northward, and are well exposed along the N. side of the stream. A bold hill, lying 400 feet to the E., on the opposite side of Towanda Creek, shows a prominent Mural cliff of red sandstone and greenish sandstone and slate, destitute of fossils. These are no doubt Ponent rocks. In the S. end of the ridge the strata dip towards the S., thus forming an anticlinal flexure with those dipping Northward.

The ore at Sellard's lies in a red belt of the Vergent rocks. The ore itself in both beds contains *Encrini*, *Atrypa punctata*, *Delthyris mucronata;* also *Cypricoides*, and several other fossils. About 8 or 10 feet of the calcareous lead-coloured shales are visible in place, at the opening of the upper ore-bed on the creek, and slabs of the rock are strewed higher up the hill. Fragments of the same rock have been procured half a mile higher up Towanda Creek, or S. of the present locality, no doubt upon the Southern dip of the strata.

The lower band, or red ore, is a highly-ferruginous red sandstone, bearing the closest possible resemblance to the block ore of the Surgent iron-sandstone. It is not surprising, therefore, that the other should be considered identical with the fossiliferous ore.

As exposed at the lower opening, it measures 3 feet in thickness, but the best portion of the band is about 1 foot thick near the bottom. From all appearances, not less than three and a half tons of this ore will be required to make one ton of iron.

This ore was not observed along the Susquehanna, nor in fact eastward of Troy, although there are numerous indications of something very like it in the red band accompanying the limestone. It may be called the Mansfield Ore, and as such I shall notice it hereafter.

A few local details will complete the description of the country East of the Tioga River.

Copper Ore occurs on the Berwick Turnpike, nine miles below Monroe Corners. At the bottom of the Ponent rocks, in a mass of red sandstone, there is a band of red and green shale several feet thick. In this shale are balls of an ore containing a small amount of green carbonate of copper. This stratum is visible on the Loyalsock and on Pine Creek.

The delta of Sugar Creek exhibits in a striking manner the action of an eddy.

THE NARROWS OF THE SUSQUEHANNA.

A short distance above the mouth of the Sugar Creek, at what are called the Narrows, the canal has been led along the west bank, and high cuttings have exposed the Vergent rocks, sometimes 40 feet high, for nearly a mile in length. It presents a very strange and picturesque appearance. The lines of stratification scarcely vary in their height above the water, and almost every stratum is well marked and straight throughout this distance. The S. dip into the hill is as much as 12°. The strata are grey argillaceous sandstones alternating with shales.

Limestone Boulders.—Throughout the valley of the North Branch of the Susquehanna, boulders of a white limestone form the outcrops of the limestones lying to the Northward in the State of New York; they were once so abundant on the surface that lime-kilns were erected for burning them. Canoes were used in obtaining the stones and conveying them to the kilns. The cross valleys contain debris of a very heterogeneous character.

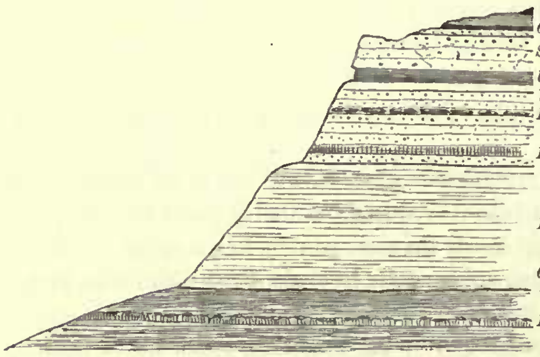


Fig. 42.—Section showing the Strata E. of the Tioga River.

These transverse or N. and S. valleys seem to have been the main channels for the passage of the waters from the North. The first, West of the Susquehanna, is that of Bentley's and Tom Jack's creeks, where the hills rise to about the same height above the water-level, at the head-waters of the two streams, as at their mouths. The second valley W. is that of South Creek and Sugar Creek, continued onward down the Lycoming Creek.

The third is that of the Tioga. This will now be described, but briefly, as much of the matter is furnished in the general sketch of the formations.

TIOGA RIVER AND COUNTRY WESTWARD.

VERGENT SHALES.

A broad belt of this formation crosses the river from above Covington to the neighbourhood of Mill Creek. Above this belt is the Armenia Mountain at Blossburg, and below it on each side of Mill Creek is the mountain of Vespertine strata. In the synclinal basin No. 4, still lower down the stream, the Vergent series comes to the day, and continues as the surface-formation into New York.

IRON-ORE STRATUM.

This is best studied at Roseville on Mill Creek, three miles from the county line. On the brow of a steep hill it has been long ago opened. It there shows a section as follows—

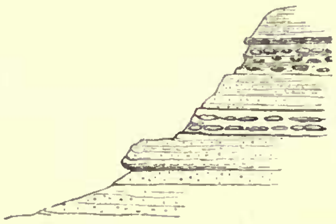


FIG. 43.—Section at Roseville.

The ore is a red, sandy, soft stone, blood-red in the streak; it lies in flags, like the Vespertine sandstone, each of which is an inch or two in thickness. The mass is 2 feet thick, but above it, over an intervening 3 feet of red sandstone, are huge balls of another variety, apparently more sandy, and certainly of less weight.

It is about 200 feet below the top of the Vergent series.

This ore is observed in many of the neighbouring hills. Sometimes it occurs so soft as to be cut and used for red chalk. In passing Northward the ore is seen in many places along the road to Elmira, and returning towards Columbia Flats, but none towards Troy. It is found on the hill at Mansfield; and many tons of it have been thrown out at a point four miles on the road from Mansfield towards Wellsborough. At this last place it is accompanied by, and is itself in the form of red shale, filled with innumerable fossils similar to those of the limestone, which, however, was observed in none of these places.

S. of Corning, on the road to Mansfield in Tioga County, there are occasional exposures of olive and grey calcareous shales of the Vergent or Chemung group, dipping gently S. These contain purple and reddish sandstones and shales, about Lawrenceville, near the State line. The alternation continues until the predominant material is red. About three miles N. of Mansfield, red shales and sandstones are exposed, dipping N. from 5° to 8°. At Mansfield, and on the hills on both sides of the Tioga Valley for some distance N. of it, the rocks are olive and grey, sandy and calcareous slates, and shales of the Vergent.

One mile S. of Mansfield the dip, though slight, is sensibly to the Southward. It would therefore appear that the anticlinal is at or near Mansfield.

The hills one mile S. of Mansfield, which are about 200 feet high, are composed of flaggy, calcareous, and sandy shale, of a greyish and olive tint, abounding in fossils. These are chiefly in the calcareous courses or partings, but their casts are also abundant in the sandy beds and in the red layers of the ore. This ore is opened about 50 feet, below the top of the hill; the diggings display sandy and argillaceous calcareous slate 5 feet thick. Beneath this is a band of red sandstone ore 6 inches thick, underlaid by 6 feet of shale and slate. Below this lies the principal ore-bed, estimated to be from 12 to 15 inches thick. It is a deep purplish brown, and has been ground by the proprietor, Mr Boxby, for use as a paint. Some of it is oolitic, or seedy, resembling some kinds of the Surgent fossiliferous ore.

I am inclined to identify this ore with that found on Pine Creek, thirteen miles on the road from Wellsborough towards Coudersport. It is visible on the hills S. of the Cowanesque, as will be noticed hereafter.

PONENT RED SHALE.

In the upper part of the river valley, this formation retains in some measure its thickness, much diminished, however, when compared with the stratum in the first basin. As we pass down the river to the fourth basin, it almost disappears, as will be seen in speaking of the Cowanesque Valley.

LIMESTONE OF THE VESPERTINE SERIES.

The limestone of the lower part of the Vespertine formation has been already noted. It overlies a bed of bluish sandstone, 8 or 10 feet thick, and appears itself in large blocks on the side of the railroad cuttings, three miles or less below Blossburg; dip S.S.E. 6° or 8°. Half a mile below this the top of the Ponent is seen. This limestone is fossiliferous.

This diagram exhibits the relative magnitude of the several formations in the escarpment S. of the third axis, but if made North of it for the Southern escarpment of the fourth basin, it should represent the Ponent rocks as rising 100 feet on the mountain-side, and capping the hills at its base. Comparing these escarpments with that of the fifth near Knoxville, we find that the latter mountain has a less elevation, while the plateau of the Cowanesque is much narrower than that of Crooked Creek; and connected with this difference the Vespertine sandstone is reduced in thickness, while the Ponent red shale has nearly disappeared. At Knoxville we see Vergent rocks at the creek dipping 2° Northward.

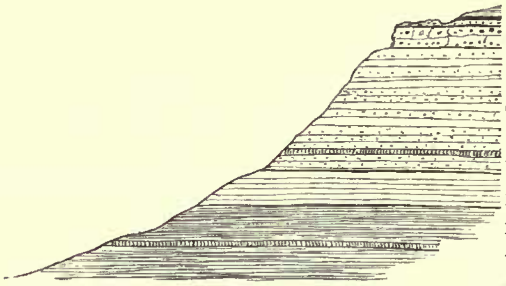


Fig. 44.—Mountain Escarpment S. of Wellsborough.

Ascending Troup's Creek a half-mile to the Saw-mill, there is an exposure of red shale, perhaps 30 feet thick, with every appearance of containing iron in the bog at its base. This band of red shale appears to be a member of the Vergent formation, and identical with the Mansfield ore stratum ; for upon ascending the strata in the mountain for more than 200 feet, we find everywhere pieces of what seems to be the green sandstones of that group. These green sandstones possess the peculiar property of producing a pinkish soil.

Above these occur the true Vespertine sandstones, seen in place, pitted with black specks, in their usual character, false bedded, and in thin layers. This rock everywhere seems to possess this false bedding. It so occurs throughout Tioga, Potter, and McKean counties. Near Knoxville the Vespertine formation seems to be about 500 feet thick, for it ascends to the heavy bench of white Seral sandstone or conglomerate. There are no marks of the Umbral red shale on the hill, but eight miles further W. traces of its ore were discovered.

The *red band* noticed near Knoxville seems to be that of the Mansfield ore. On one of the high hills to the S. and nearly upon the axis, the Mansfield ore appears in its proper position, but wonderfully degenerated in size, and totally worthless in quality. It is there accompanied by red soil, and the dip between the two positions would go far to identify them.

This place is about eight miles S.E. from Knoxville, on the road to the Crooked Creek Forks. No limestone was observed there, nor at Knoxville, although at the latter place it must lie close under the surface, as it is opened on the Cowanesque two miles below Knoxville, in a poor band, two feet thick, and fossiliferous. This proximity of the limestone is another proof that this red band is not Ponent, but the Mansfield ore-bearing red stratum of the Vergent series. Now, if it be not the Ponent, that formation is not to be found at all in this basin.

The limestone is found in the next basin to the S., in the hill behind the court-house in Wellsborough. Here it is in numerous bands, the uppermost and lowermost probably 100 feet apart. It has an aggregate thickness of many feet of very fossiliferous rocks. One mile and a half from the town, on a road towards the S., there is a deposit of travertin in an extensive dry bog. It appears collected upon the moss now growing there, and is impressed with the forms of the vegetation. The travertin has been brought down the hill by the small brooks.

This bed of travertin extended over an acre, and was from 6 inches to 3 feet deep. It has been burnt, and makes very fine white lime. The Mansfield iron-ore underlies the plot of ground on which Wellsborough is built. An excavation made anywhere, to the depth of 3 or 4 feet, will develop a band of sandy iron-ore about 5 inches thick.

A SINGULAR LAKE.

On the road from Wellsborough down Crooked Creek, there is a low ridge of the form called Hogsback. A traveller may look to the right over the marsh, which fills up the bottom of the valley, and to the left into a pond which has neither inlet nor outlet. The lowest portion of the dam is 12 feet above its water-level, and yet its edge comes within 60 feet of the edge of the marsh. It is surrounded, except on the marsh side, by high, steep hills, and is in fact a cove in the mountain.

Drift.—The phenomena connected with the drift or diluvium which strews the surface of this district, will be described and discussed in the general Chapter devoted to the consideration of this great superficial formation.

BOOK V.

FIFTH OR LOWER JUNIATA DISTRICT, BEING THE SOUTH-EASTERN HALF OF THE APPALACHIAN CHAIN BETWEEN THE SUSQUEHANNA AND MARYLAND.

DIVISION I.

FIRST AND SECOND SYNCLINAL, AND INCLUDED ANTICLINAL BELTS, EMBRACING PERRY AND THE NORTH-WESTERN PORTION OF FRANKLIN COUNTY.

This is a natural subdivision of the Appalachian region, lying between the Cumberland Valley on the S.E., and the Tuscarora Mountain on the N.W. Its geology will be best described in connection with the remarkable system of axes which traverse the district.

Perry County, where it is bounded on the N.E. by the Susquehanna River, has a simple geological structure. It consists of two great synclinal troughs, embracing formations as high in the system as the Umbral red shale. These troughs are extensions of the synclinal axes of the Dauphin County and Lykens Valley coal-basins. In this there is an analogy to the Valley of Juniata County. Towards the central part of the county, this simplicity disappears; the higher formations crop out and terminate; and a complex, though regular group of anticlinal axes originates, which range South-westward in lower formations, many of them passing into Franklin County, where, in some of the valleys, they lift the Auroral limestones to the surface.

The reader is recommended to consult frequently, while he is perusing the following chapters, the Geological Map illustrating the structure of the districts described, with the General Sections appended to this Map, and the local ones introduced into these pages.

CHAPTER I.

STRUCTURE OF PERRY AND WESTERN PART OF FRANKLIN COUNTY.

SHERMAN'S VALLEY.

This is the largest portion of Perry County, and has the form of a general valley. In its widest part, Sherman's Valley lies between the Tuscarora Mountain on the N.W., and the Cove and Blue Mountains on the S.E., with an average width of fourteen or fifteen miles, having about the same extent South-westward from the Juniata. In the neighbourhood of Landisburg, which is situated near its S.E. side, several mountain-knobs rising, detach small and distinct valleys from it, by which it is much contracted in breadth towards its South-western portion. This South-western section of the main valley lies between Bower's Mountain on the S.E. and the Conecocheague on the N.W. The South-western part of Sherman's Valley has an average width of four or five miles, and is bounded S.W. by three mountain-knobs, which rise in it S.W. of Germantown. The surface of Sherman's Valley is exceedingly diversified, a number of ridges subdividing it into minor valleys, chiefly without name. Sherman's Creek traverses it from one end to the other.

FLEXURES IN THE STRATA OF SHERMAN'S VALLEY.

Anticlinal Axes.—There are *nineteen* anticlinal flexures in this valley, which influence several *formations*. Ten of these do not pass the S.W. limits of the valley, but the remaining nine elevating lower rocks are prolonged South-westward into North Horse Valley, Burns's Valley, Path Valley, Amberson's Valley, and the Cumberland Valley. These axes, with a few exceptions, are parallel. They curve gently towards the S., in accordance with the general bend of this part of the chain. The dip of the strata in these flexures is, in the majority of instances, steeper on the N.W. than on the S.E. sides, though there are exceptions to this the usual condition. The numerous axes of this group are not susceptible of subdivision. We shall treat them, therefore, in one series, beginning in the present instance with those on the N.W.

Some of them arise many miles to the S.W. of others, but they finally overlap. I shall designate them numerically, to avoid circumlocution; and, after giving a somewhat minute description of the range of each, shall trace the course of the several formations as controlled by them. (See the Sections of Sherman's Valley.)

First, or most North-western Anticlinal Axis.—This originates at the S.W. end of Racoon Valley in the Surgent Rocks. It passes half a mile N.W. of Jacksburg, and about the same distance N.W. of Linn's Mill, into the middle of Liberty Valley, until it elevates the Levant sandstones in the mountain-knob in that valley, at what is termed the Locking of the Mountains. Ranging further South-westward, it enters North Horse Valley, being the main axis of this valley, which it traverses centrally. From the mouth of North Horse Valley it extends into Path Valley, dying away gradually in the Matinal slates, near the base of the Tuscarora Mountain, five or six miles S.W. of Concord. This axis is thirty miles in length. It takes a gentle sweep towards the S., and is very regular.

Second Anticlinal Axis.—This is about half a mile S.E. of the preceding. It originates in the Cadent rocks, two or three miles N.E. of Ickesburg, and passes the S.E. border of that town, whence it extends in a straight line S.W. to the point of Conecocheague Mountain at Linn's Mill. It is the axis of that mountain. It finally passes into the E. corner of North Horse Valley, where it dies away in the Matinal slates. It is sixteen miles in length.

Third Anticlinal Axis.—The N.E. extremity of this flexure is in the Post-meridian rocks S. of Racoon Ridge, and one or two miles E. of the McKenzie Mill. Ranging thence South-westward in a straight line, it runs one third of a mile or less S.E. of Ickesburg, S.W. of which town it flattens out in the Surgent shales. It is parallel to the second axis, and one-third of a mile from it. Its length is eight or nine miles.

Fourth Anticlinal Axis.—The fourth axis originates in the Cadent rocks, a mile and a quarter S.E. of Ickesburg. It extends South-westward for about six miles, crosses Buffalo Creek a mile or more to the S.E.

of Linn's Mill, and finally disappears in the Surgent shales S. of the Conecocheague Gap, not far from the base of the mountain. It is nearly three-fourths of a mile S.E. of the third axis.

Fifth Anticlinal Axis.—This originates in a narrow belt of the Cadent rocks, a few hundred yards S.W. of Bixler's Mill, and perhaps half a mile S.E. of the end of the preceding. Traced S.W., it takes the centre of the ridge between Andersontown and the Conecocheague Mountain. From the end of this ridge we trace it in the Surgent shales and slates for many miles, passing a few hundred yards N.W. of Germantown to the Round Top Knob, four and a half miles S.W. of that place. It is the axis of Round Top which divides South-westward into two crests, to encircle Burns's Valley, the axis passing into the Matinal slates of that valley, and extending into Path Valley, where it lifts to the surface the Auroral limestones, and becomes the main anticlinal. It passes a short distance S.E. of Dry Run, S.W. of which point it makes a considerable curve towards the W., in connection with the dying away of the first axis in the slate to the N.W. of it. It then assumes its original bearing, and ranges S.W. in a straight direction for many miles. It passes about half a mile N.W. of Fannettsburg, and about the same distance N.W. of Carrick Furnace. Extending still South-westward, it re-enters the Matinal slates a few hundred yards S.E. of the Old Mount Pleasant Ore Bank, and one and a half miles further to the S.W. it passes into a nook on the S.E. side of the Tuscarora Mountain, being here saddled by the Levant sandstone. It thence ranges as a huge mountain axis for several miles, until it terminates against the S.E. side of the mountain bounding the Cove opposite McConnellsburg. This anticlinal axis is forty-one miles in length, having a general curve to the S., with the one slight inequality of sweep which has been noticed.

Sixth Anticlinal Axis.—The N.E. extremity of the sixth axis is in the Vergent shales, about three miles S. of Ickesburg. It ranges thence South-westward, passing one-fourth of a mile S.E. of Bixler's Mill, and three-fourths of a mile N.W. of Andersontown. It passes near the Stone Church, between the latter place and Germantown, and a few hundred yards S.E. of Germantown, ranging whence South-westward, it enters between the Round Top and the Rising Mountain, and gradually flattens out, affecting the Levant white, red, and grey sandstones, so as to form a flexure or imperfect knob, with concavities towards Burns's Valley. This axis is nearly parallel to the fifth, and about half a mile S.E. of it. It makes a gentle curvature, and is eighteen or nineteen miles long.

Seventh Anticlinal Axis.—The seventh anticlinal axis originates two miles or more N.E. of Andersontown, and passes a few hundred yards S.E. of it. Traced S.W., it is the axis of Buck Ridge, being here about a mile S.E. of Germantown, and it is prolonged into the Rising Mountain, which becomes cleft along it. The axis then passes into the Matinal slates in the N. corner of Amberson's Valley, where it flattens out. This axis is three-fourths of a mile S.E. of the sixth, and is about sixteen miles in length.

Eighth Anticlinal Axis.—This flexure extends for a great distance through Perry and Franklin counties. We first observe it a short distance W. of the Juniata Furnace, whence for three or four miles South-westward it occupies the N.E. flank of the limestone ridge, passing three-fourths of a mile N.W. of Bloomfield. Thence it is to be found in the centre of the limestone ridge for five miles further, where it passes into the Surgent shales, ranging near the base of that ridge. Beyond the end of the limestone ridge it stretches on, passing some distance to the S.E. of Holabaugh's Mill, and becomes the axis of the second ridge S.E. of Germantown, and of Amberson's Knob. Amberson's Knob separates into two crests, and the axis passes into the Matinal slates in Amberson's Valley between the two knobs in its N.E. end. We thence trace it through the central part of Amberson's Valley, out of which it passes into Path Valley, ranging along its S.E. side in the Matinal slates. It is close to the base of the S.E. bounding mountain, and passes out of the mouth of Path Valley, near Loudon, becoming the axis of the most Western of the three limestone belts in the Western part of Franklin County. Its S.W. termination has not been examined, but it ranges across the State of Maryland, probably nearly to the Potomac.

From the origin of the eighth anticlinal axis at Juniata Furnace, to the point where it brings up the Auroral limestones, N. of Loudon, the distance is more than fifty miles. It observes a very regular curve, beginning S. 45° W., and crossing Maryland in a line S. 25° W.

Ninth Anticlinal Axis.—The N.E. commencement of the ninth axis is a mile or more S.W. of Creigh's

Furnace, or two miles S.E. of Newport on the Juniata, near the S.E. base of a high ridge of the Cadent grey sandstone. It first appears in the Cadent lower black slate. Traced South-westward, it occupies the summit of the limestone ridge for eight miles, passing one-fourth of a mile S.E. of Juniata Furnace, and half a mile N.W. of Bloomfield. Two miles W. of the latter place it passes out between a spur of the limestone ridge and the main ridge into the Surgent shales, ranging in these South-westward to Waggoner's Mill, eight miles distant, when it becomes the axis of a considerable ridge, consisting principally of the Surgent iron sandstone. This ridge, representing the course of the axis, stretches S.W. from Waggoner's Mill nine or ten miles, ending against the flank of Bower's Mountain, opposite the irregular curve, and three miles S.E. of Germantown. The ninth axis is twenty-five miles in length, and about half a mile S.E. of the eighth, diverging from it towards the South-west.

TENTH ANTICLINAL AXIS.—This is the only one of the axes of Sherman's Valley which extends S.W. to the Juniata River. It is one of the axes of the anthracite coal region. It crosses the Susquehanna at the Half Falls, and is the axis of the Half Fall Mountain. It crosses the Juniata River at its falls, four miles above Duncan's Island. Traced thence South-westward, it becomes the axis of the little valley of Bloomfield, ranging between the Limestone and Mahanoy ridges. The town of Bloomfield is situated on it, S.W. from which it preserves a distance of one-fourth of a mile from the base of the Mahanoy Ridge. Beyond the end of the Mahanoy Ridge, pursuing the same direction, it passes Loystown, and one or two miles S.W. of this place it dies away in the Surgent slates. There is a slight swerving of this axis to the W. a few miles S.W. of Bloomfield. From the Susquehanna at the Half Falls to its S.W. extremity the distance is 23 or 24 miles. This axis of the Half Fall Mountain, after crossing the Susquehanna eastwardly, is seen ranging in the Ponent rocks through the centre of Armstrong's Valley, and into the cove or nook between the Short and Berry's Mountains, thence through the knob of the latter mountain and out into the Umbral red shales of Williams's Valley; and crossing the head of this, it outcrops in the mountain barrier of the Swatara Coal-field, and dies out finally in the coal-field towards the Schuylkill. Its total length is therefore not less than 60 miles.

ELEVENTH ANTICLINAL AXIS.—The eleventh axis is three or four miles in length. It lies one-third of a mile S.E. of the preceding. It originates about three-fourths of a mile E. of Elliottsburg, in the neighbourhood of Perry Furnace Ore Bank, and terminates E. of Loystown in the Surgent shales.

TWELFTH ANTICLINAL AXIS.—This is about one-third of a mile S.E. of the preceding axis, and parallel to it. It originates and dies away nearly opposite the ends of the other. It is one-fourth of a mile S.W. of the next succeeding, which is a more important line of elevation.

THIRTEENTH ANTICLINAL AXIS.—This originates in the Vergent shales S.E. of Mahanoy Ridge, about one mile from Bloomfield. It extends thence in a straight line to the end of Bower's Mountain, of which it is the axis. In this part of its course it passes three-fourths of a mile S.W. of Perry Furnance, and a mile and a quarter N.W. of Landisburg. The axis enters Bower's Mountain west of its extreme end, which is obliquely denuded.

The axis in Bower's Mountain has an irregular curve S.E. of Germantown. It bends W., and then resumes its original bearing. S.W. of this inflection, the axis occupies a narrow valley formed by the separation of Bower's Mountain into two crests, between which it passes into Amberson's Valley. It extends in the Matinal slates along the S.E. side of Amberson's Valley, and enters a slender valley to the S.E. of Clark's Knob. It is soon saddled by the Levant sandstones, and passes from a mountain-knob which juts forward into South Horse Valley, three miles W. of Roxbury, beyond which the axis dies away along the N.W. side of that valley opposite Fannettsburg. The line of elevation thus traced is 40 miles long. It has a general curve, with convexity North-westward, except at the slight flexure which has been noticed.

FOURTEENTH ANTICLINAL AXIS.—This is three-fourths of a mile S.E. of the preceding, and parallel to it. It commences a mile or two N.E. of Perry Furnace in the Vergent shales, and passes a short distance N.W. of the Furnace, from which it ranges in a straight line South-westward, passing a little N.W. of McAffee's Fulling Mill, and one-third of a mile N.W. of Landisburg, and dies away in the mouth of Shaeffer's Valley in the Surgent shales. This axis is seven or eight miles in length.

FIFTEENTH ANTICLINAL AXIS.—This flexure is one-fourth or one-third of a mile S.E. of the fourteenth axis, and parallel to it, originating and dying away in the same manner. Its North-eastern extremity is nearly one mile S.W. of Perry Furnace. Thence South-westward, we trace it ranging S.E. of McAffee's Fulling Mill, and along the S.E. border of Landisburg, to die away in the entrance to Shaeffer's Valley near Sherman's Creek. It is about four and a half miles long.

SIXTEENTH ANTICLINAL AXIS.—This is the North-western and main axis of Dick's Ridge. It originates one or two miles S.W. of the Juniata River, and three-fourths of a mile S.E. of the Mahoning Ridge in the Vergent shales. Traced South-westward, its course is along the S.W. flank of Dick's Ridge throughout its whole length. Beyond where the ridge terminates, the axis extends for four or more miles, ending three-fourths of a mile S. of Perry Furnace. It is eleven miles long, and curves Southwardly.

SEVENTEENTH ANTICLINAL AXIS.—This is one-third of a mile S.E. of the preceding, but extends much further to the S.W. It rises a mile or two S.W. of Montebello Furnace in the Vergent slates, and passes S.W. into the broad S.W. extremity of Dick's Ridge; whence we trace it in nearly a straight line for six miles, passing one mile S.E. of Perry Furnace. It there curves towards the W. to enter the mountain-knob called Pilot Hill, south of Landisburg, and finally resuming its original direction, passes out into the Cumberland Valley, through Dublin Hollow. It is now the axis already described as extending along the N.W. side of the Cumberland Valley past Roxbury and Strasburg, and W. of St Thomas, and thence through the middle of the Second Zone of Auroral limestones to the Maryland line and the Potomac into Virginia.

EIGHTEENTH ANTICLINAL AXIS.—This originates with the preceding, S.W. of Montebello Furnace, and passes along the S.E. side of the broad N.W. extremity of Dick's Ridge, from which it runs S.W. parallel to the Seventeenth Axis, and one-third of a mile S.E. of it. It ranges half a mile N.W. of Gibson's Mill, and the same distance S.E. of Waggoner's Mill, and enters the ridge which is at the base of Welche's Knob, along the S.E. side of the entrance of Kennedy's Valley, where it vanishes in the Surgent iron sandstone. This axis is twelve or thirteen miles in length.

NINETEENTH ANTICLINAL AXIS.—This originates near Gibson's Mill, and passes thence South-westward, being a few hundred yards N.W. of the Warm Spring in the Quaker Hill, and entering Welche's Knob, it passes out into the Cumberland Valley through the re-entering angle in the Kittatinny Mountain, S.E. of McClure's Gap. The Nineteenth Axis is nearly straight. It is half a mile S.E. of the Eighteenth, and parallel to it. The distance from its origin to Welche's Knob is four or five miles. In the Cumberland Valley this axis ranges many miles to the S.W. in the great belt of Matinal slates, expiring probably in Franklin County.

NORTH HORSE VALLEY—BURNS'S VALLEY—PATH VALLEY—AMBERSON'S VALLEY.

These several valleys are really all divisions of one, and I shall therefore describe them together. Several anticlinal axes, ranging from Sherman's Valley, elevate the Levant sandstones, and produce mountains, passing from which into the Matinal slates, they include between them synclinal mountain-ridges of the same Levant sandstones. See the following Sections through Path Valley and its branches.

NORTH HORSE VALLEY.—This valley lies chiefly in Perry County. It is bounded on the N.W. by the Tuscarora Mountain, and on the S.E. by the Conecocheague Mountain. It is a narrow valley, the mountain-slopes nearly meeting at their base, though it is slightly wider at its N.E. extremity, where a high synclinal knob of the Levant sandstones projects into it, and separates it into two short divisions. That on the S.E. is nothing more than a deep ravine or hollow; the other, on the N.W., is a mile in length, and a more decided valley, ending by the meeting of the knob with the Tuscarora Mountain. Horse Valley is about twelve miles in length. Its N.E. extremity is closed, but its S.W. opens into Path Valley at Concord.

Burns's Valley.—This is a small area lying between the *Round Top* and the Dividing Mountains enclosed to the N.E. by the union of these, and opening into Path Valley to the S.W. It is separated from North Horse Valley by the synclinal knob of Round Top, which, ending S. of Concord, the two valleys unite into one, called, from this point South-westward, "Path Valley."

Path Valley.—This pleasing valley is bounded on the N.W. by the Tuscarora Mountain. Its N.E. extremity for six or seven miles is bounded on the S.E. by the Dividing Mountain which separates it from Amberson's Valley. The Dividing Mountain is synclinal, and ends five miles N.E. of Fannettsburg, where the two valleys unite under the name of Path Valley. From the union of Amberson's Valley with it, it is bounded on the S.E. by a high straight mountain of the Levant sandstones without name, which terminates near Loudon in Jordan's Knob. This mountain and Tuscarora Mountain gradually converge, so that the S.W. extremity of Path Valley is narrow where it opens into the great Appalachian valley about Loudon. The length of Path Valley is twenty-two miles. Between the Dividing and Tuscarora Mountains it is nearly three miles wide; and S.W. of the end of Dividing Mountain it is wider. Towards the S.W. it is much narrower, the distance between the mountain-bases being about a mile and a half. The waters draining Path Valley pass out in opposite directions, to the Conecocheague and to Tuscarora Creeks.

Amberson's Valley.—The main portion of this valley lies between the Dividing Mountain and a mountain called the Kittatinny, which is a prolongation of the South-east-dipping strata of Bower's Mountain. Two synclinal knobs of the Levant sandstones stand forward into the North-eastern end of Amberson's Valley, and three subordinate little valleys, like so many fingers from a hand, extend between and on either side of the knobs. They are without names. In a line with the more South-eastern of the two knobs, and four miles S.W. of it, is a mountain summit called Clark's Knob, the South-east-dipping strata of which range from the S. bounding mountain of Path Valley. A narrow and unnamed valley extends between Clark's Knob and the Kittatinny or Bower's Mountain. By the presence of Clark's Knob, the S.W. portion of Amberson's Valley is much narrowed between that knob and the Dividing Mountain. The width of Amberson's Valley, between the Kittatinny and Dividing Mountains, is a mile and a half, and between the latter and Clark's Knob and the mountain extending from this South-westward, it is only half a mile wide. It opens into Path Valley by the ending of the Dividing Mountain, being eight or nine miles in length.

The four valleys thus described are, of course, anticlinal valleys or valleys of elevation. They are occupied by the Matinal slates, except Path Valley, the central tract of which exposes the Auroral limestones. These valleys possess an even surface, and are well cultivated.

STRUCTURE OF PATH VALLEY.

Path Valley is traversed by three anticlinal axes, the first, fifth, and eighth of our enumeration. The first, or main axis of North Horse Valley, passing into the Northern part of Path Valley, dies away in the Matinal slates. The eighth, passing from Amberson's Valley, ranges along the side of Path Valley, out of which it passes to the N.E. of Loudon. It does not develop the Auroral limestone in Path Valley, being confined to the Matinal slates.

It is the fifth anticlinal axis, which, passing from Burns's Valley, brings to the surface the Auroral limestones as they are found in Path Valley.

FAULT IN PATH VALLEY.

There is an extensive fault on the N.W. side of Path Valley, which we shall describe previously to giving a detailed account of the formations. This extends for 13 miles along the base of the Tuscarora Mountain. The most North-eastern point, where the fault can be detected, is opposite the end of the Dividing Mountain, 4 or more miles N. of Fannettsburg. It is there a simple dislocation, in which the Auroral limestone is heaved up along the fissure, into contact with the Matinal slate. Both formations dip N.W., the lowest one 40°, and the slate 60°. Fig. 45 exhibits a Section of the fault.

From its N.E. origin to a point W. of Fannettsburg, a distance of more than 5 miles, the fault has the same

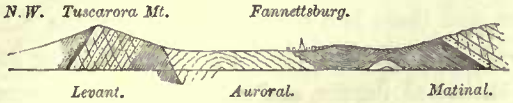


Fig. 45.—Section at Fannettsburg.

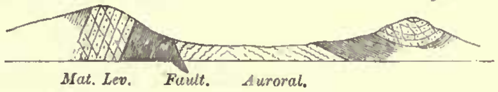


Fig. 46.—Fault opposite the end of Dividing Mountain.

character, more and more of the Matinal slate disappearing, until it is nearly lost. The line of the fracture is near the steep slope of the mountain, and is indicated by a row of sinkholes, where the water, draining from the more impermeable strata, seeks subterranean passages in the limestone. Here is a section opposite Fannettsburg, where much of the slate disappears.

W. of Fannett's, where the road to the Burnt Cabins crosses the mountain, the fault loses its simplicity, a large wedge of the Levant white sandstone, and at one point a portion of the Surgent slates, being included between the two fissures, of which the dislocation here consists. A section, a few hundred yards W. of Carrick Furnace Ore Bank, would be as follows: Auroral limestone, dip 30° N.W.; and upon that iron ore and Matinal slates crushed along the fault. In contact with the slates the Levant sandstone dips 40° N.W., following a terrace to the mountain, which supports some Surgent slates. The house on the mountain is situated upon these slates, and the Levant sandstone composes the crest of the mountain, and dips N.W.

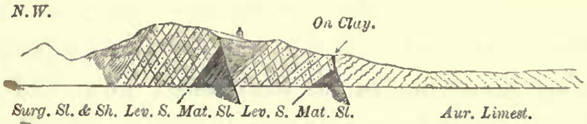


Fig. 47.—Section near Carrick Ore Bank.

Tracing the fault S.W. from the road mentioned, the included wedge of sandstone extends in close contact with it for 2 miles, with a N.W. dip. The sandstone mass, however, becomes smaller, and descends on the flank of the mountain, so that the Matinal slates appear above it, and at the termination of the wedge the slates, forming a considerable belt on the mountain-slope, are in contact with the limestone of the valley along the fault. The sandstone fragment forms a bench on the mountain, which is cut by three or four gorges. The Surgent slates form a circumscribed patch of the lower slates merely.

The two following Sections (see figs. 48 and 49) represent the fault towards the S.W. end of the wedge or fragment, and beyond its extremity.

Fig. 48.—Fault near S.W. end of Sandstone Wedge.

Fig. 49.—Fault S.W. of the Sandstone Wedge.

For two miles and a half S.W. of the wedge, within the fault, the slate and limestone are in contact, a fact indicated by a row of sinkholes. Towards the end of that space the slate exhibits a contortion, or short axis, so that along the fissure the slate dips S.E., and the limestone steeply N.W.; and further South-westward, opposite to Cowan's Gap in Tuscarora Mountain, some of the lower rocks of the Levant series, with a S.E. dip, lie on the slate along the fault, in contact with the limestone.

The following is a Section representing the attitudes of the strata at that point. (See fig. 50.)

This sandstone forms a low ridge, which becomes united with the base of the mountain S.W. of the Gap, as the axis in the slates on the S.W. of it gradually disappears. The fault, for a mile S.W. of a point opposite the Gap, brings the limestone and sandstone, as above mentioned, together; but further on we find some slate

FIG. 50.—Section of the Fault opposite Cowan's Gap.

FIG. 51.—Section of Fault at the Old Mount Pleasant Ore Bank.

with a N.W. dip on the S.E. side of the fault, and at the Old Ore Bank of the Mount Pleasant Furnace we have the state of things shown in the accompanying Section, fig. 51. The fifth anticlinal axis is no longer saddled by the Auroral limestone, but by the Matinal slates, and there is a steep N.W. dip on the S.E. side of the fault. Crushed slate and ore lie in the fault, and on its N.W. side white sandstone, dipping 35° S.E. High on the mountain the Matinal slate appears in an anticlinal flexure, and in the crest of the mountain the Levant sandstones dip N.W.

From the ore-bank the fault extends towards the nook in the Tuscarora Mountain, which marks the entrance of the fifth anticlinal axis, and there becomes rectified in the Matinal slates. The South-east-dipping sandstone N.W. of it ends on the mountain as the short axis in the slate above it dies away, the mountain becoming monoclinical with a N.W. dip.

This local mass of sandstone, dipping into the fault, is one mile or more in length, and not more than 40 or 50 feet thick.

AURORAL LIMESTONE IN PATH VALLEY.

COMPOSITION.

The rocks of Path Valley consist principally, if not entirely, of the Auroral magnesian limestone, and the Matinal slates. Black argillaceous limestone and calcareous slates, without fossils, and only a few feet in thickness, separate these formations. This is probably the Matinal slaty limestone in an attenuated form, the Matinal older slate not being present here. The black slates have, in some instances, apparently a small amount of the protocarbonate of iron, which has been converted into the peroxide by atmospheric action, and encrusts the surface of the rock, but in no place observed does it form an ore of the slightest value. It presents, however, an example of the association of iron in that form with carbonaceous shales, which occurs frequently in some of the higher formations.

The Auroral magnesian limestone in Path Valley consists almost entirely of thick beds of more or less pure limestone. The light blue magnesian limestone is abundant, alternating with strata of a deeper blue and purer composition, without any marked order of distribution. The magnesian rock seems in many places to have been used unsuccessfully for making lime; some portion of it would, no doubt, answer well for making hydraulic cement. Fossiliferous beds of blue silicious limestone occur in the central part of the belt, but none are visible in the upper strata.

GEOGRAPHICAL DISTRIBUTION.

The Auroral limestone forms an undivided zone, occupying the N.W. portion of Path Valley. It is anticlinal, with rather gentle dips. The axis, the fifth of our enumeration, passes from the slate in Burns's Valley into the limestone about 12 miles N.E. of Fannettsburg, and half a mile from the N.W. base of the Dividing Mountain. Tracing the limestone from that point S.W., it forms a widening belt, the S.E. margin of which is a few hundred yards from the base of the Dividing Mountain. Its N.W. edge crosses the valley diagonally, in connection with the dying out of the Horse Valley anticlinal axis in the Matinal slate to the N. of it, so that it reaches the base of the Tuscarora Mountain opposite the extremity of the Dividing Mountain, which is near the origin of the Great Fault. Thence South-westward the fault marks the N.W. limit of the limestone for 12 miles, lying close to the base of the mountain. The S.E. edge of the limestone, from opposite the end of the Dividing Mountain, extends S.W. in nearly a straight line, distant about three-fourths of a mile from the base of the S.E. bounding mountain of the valley. It passes along the S.W. side of Fannettsburg, and to the S.E. of Carrick Furnace, the two borders meeting, and the limestone vanishing in a point, about 7 miles S.W. of Fannettsburg, and a few hundred yards E. of Old Mount Pleasant Ore Bank. The Auroral limestone thus constitutes a belt about 19 miles in length. It is $1\frac{3}{4}$ miles in breadth W. of the end of the Dividing Mountain, but narrows towards its extremities. The anticlinal line to the N.E. of Fannettsburg is nearly central, but South-westward of that place it is nearer the N.W. side. The dips on the S.E. side are uniformly 30° to 40°, and those to the N.W. of the axis are about the same, but become steeper towards the S.W. The relation of the limestone to the higher formations along the fault has been spoken of. The surface of the limestone is undulating. It is so much covered by transported sand and loose rock near the Tuscarora Mountain that it is nearly barren, but the S.E. portion of the belt is fertile and well cultivated.

Auroral Limestone exposed along the Eighth Anticlinal Axis on the South-east Axis of Path Valley.—This axis elevates the limestone in the mouth of Path Valley one mile or more N. of Loudon, from whence it extends S.W., being the most Western of the belts which traverse Franklin County in the neighbourhood of Loudon and Mercersburg. The limestone rock does not pass into Path Valley, but is overlaid by slate to the N.E. opposite Jordan's Knob. It is entirely covered by debris, but can be detected by sinkholes.

MATINAL SLATES IN PERRY AND FRANKLIN COUNTIES.

COMPOSITION.

The thickness of the Matinal slates could not be estimated, but it is evidently great. The mass consists chiefly of olive-coloured slate, with thin beds of grey and olive sandstone, and it would seem to appertain entirely to the Matinal formation.

GEOGRAPHICAL DISTRIBUTION.

Matinal Slate in North Horse Valley.—North Horse Valley is entirely underlaid by this formation. It is traversed centrally by the first anticlinal axis, which is the main axis of the valley, while the second axis dies away in the slate in the Eastern corner of the valley, which is there widest. The slate extends perhaps one-third of the height of the bounding mountains, forming gentle slopes on either side, which descend to meet at the streams. The strata of the North-western side dip N.W. 80°; and on the South-east side, more gentle, 45°. The slate is much covered by debris in the N.E. end of the valley, rendering it barren, but to the S.W. the surface is rather well cultivated and undulating, though cut into shallow ravines.

The slate formation, passing from Horse Valley into Path Valley, unites around the end of Round Top Knob with the slates of Burns's Valley.

Matinal Slate in Burns's Valley.—This little valley is composed of the Matinal slate, traversed by the fifth and sixth anticlinal axes, the latter dying away in its S.E. side, near the base of the Dividing Mountain. The slate ascends one-fourth of the height of the bounding mountains, occupying the gentle part of the slope. It is much covered by debris. The slate of Burns's Valley is subdivided near the entrance of the valley by the intrusion of the Auroral limestone along the fifth axis. That on the S.E. ranges S.W. at the base of the Dividing Mountain. That on the N.W. meets with the slate of North Horse Valley, forming a broad district in the N.E. end of Path Valley.

Matinal Slate in Path Valley.—The slate formation extending from the extremities of Horse Valley and

Burns's Valley, has three dips, being traversed by the first axis. This axis, flattening out the S.E. limit of the slate, approaches the Tuscarora Mountain until the formation becomes monoclinal, opposite the end of the Dividing Mountain, and near the origin of the fault. The slate district thus traced is near two miles wide S.W. of the Round Top, extending up the slope of the Tuscarora Mountain.

Matinal Slate North-west of the Fault.—The slate at the N.E. end of the fault is entire, with a dip of 60° N.W. Followed to the S.W., the lower strata gradually disappear, and the belt becomes narrower until N. of Fannettsburg the formation is nearly lost, being merely represented by clay, formed by the crushing of the slate. Thence for two or three miles S.W. to the extremity of the sandstone or wedge before described, the Auroral limestone and Levant sandstone are nearly in contact, being only separated by clay containing brown iron-ore. The slate appears on the N.W. side of the detached sandstone mass towards its S.W. end, and beyond it forms again one united belt, reaching high on the flank of the Tuscarora Mountain, and in contact with the limestone along the fault. This condition continues for several miles S.W. as far as the Gap, where, as before stated, the Levant grey sandstone, with S.E. dip, lies along the fault against the limestone, between which and the sandstone of the mountain the slate exists in an anticlinal attitude.

The slate, lifted by the short axis, passes S.W. along the S.E. flank of the mountain. The formation appears along the S.E. side of the fault, E. of Mount Pleasant Ore Bank, with a steep N.W. dip, and then folding over the anticlinal axis in the limestone, meets the slate of the S.E. side of Path Valley to underlie the whole valley, extending up the flanks of the bordering mountains.

Iron Ore in the Matinal Slate along the Fault.—All the *iron ore* of Path Valley is on the line of the fault. Two conditions probably have conduced to its formation. The sandstone of the mountain is much shivered and fissured, allowing the water to penetrate it freely; and the slate has been crushed into a condition favourable to the retention of the oxide of iron conveyed by the filtrating water from the sandstone. At Carrick Furnace Ore Bank, the ore lies in a bed of limestone clay, which rests on limestone, and seems to have been instrumental in arresting the deposit. It is found at various points along the whole line of the fault, which may be easily discovered by a row of sinkholes. The ore does not exist as a continuous bed, for good exposures of the walls of the fault may be seen where it is not found. The greatest body of ore exists, no doubt, in that portion of the fault which passes N.W. of Fannettsburg, extending for several miles, perhaps for six or eight. The crush has there been greatest, and all the other circumstances are more favourable than elsewhere. The quantity is probably immense. From the end of the included fragment of sandstone to the Old Mount Pleasant Ore Bank, the ore seems not to exist in a large body, for the slates and limestone can often be seen in close contact without any intervening clay.

Carrick Ore Bank is on the fault W. of Fannettsburg. Large quantities of ore have already been removed. The subjoined Section will show its position. The clay above the ore is very tough and black, and constitutes a large mass. It is highly impregnated with the sulphuret of iron, which might possibly be made a source of manufacture.

The ore in this bank was discovered to be a bed dipping with the limestone, and nearly 30 feet thick at the surface, but thinning downwards into a wedge. There are, S.W. of the chief Carrick Ore Bank, several other excavations in which the ore is found in large angular masses loose in the clay. These have evidently been torn from a solid bed by the action of watery currents; and it may be mentioned here that Path Valley, S.W. of Fannettsburg, is much strewn with rounded masses of the ore, showing that a violent inundation has invaded the district since the formation of the ore.

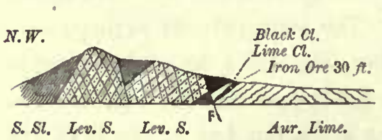


FIG. 52.—Fault at Carrick Ore Bank.

Mount Pleasant Ore Bank.—This is now abandoned. It is on the fault near its S.W. end, where it is entirely in the slate. Immense excavations have been made here, and ore has been mined in small quantities at several other points. Its discovery is easy, by simply tracing the fault as we have described it.

For the external characters and constitution of these ores, the reader must consult the special Chapter on the Iron Ores of the State.

Matinal Slate North-west of Dividing Mountain.—The matinal slate extends along the N.W. base and flank of Dividing Mountain, reaching one-third of its height with an uniform dip, about 35° S.E. Its N.W. border is the Auroral limestone.

At the end of the mountain it meets the slate of Amberson's Valley.

Matinal Slate in Amberson's Valley.—This valley is entirely underlaid by the slate formation, which reaches, as usual, about one-third of the way up the slope of the bounding mountains. It extends in tongues of anticlinal form between and on either side of the two knobs in the N.E. end of the valley. The seventh anticlinal axis, passing from between the Northern knob and the Dividing Mountain, dies away in the slate in the north corner of the valley. The eighth anticlinal axis issues from between the two knobs, traverses the middle of Amberson's Valley, and passes out into Path Valley.

The thirteenth anticlinal axis, or that of Bower's Mountain, ranges along the S.E. side of Amberson's Valley in the slate, passing into a narrow valley between northern Clark's Knob and the (false) Kittatinny Mountain, into which a very slender belt of the slate extends.

The portion of Amberson's Valley which lies between the mountain ending to the N.E. in Clark's Knob and the Dividing Mountain, is composed of the slate with the eighth axis in the centre. The surface of Amberson's Valley is in many parts covered with local drift from the adjacent ridges, and is thinly populated.

Matinal Slate South-east Side of Path Valley.—From the mouth of Amberson's Valley a broad belt of slate extends along the S.E. side of Path Valley with three dips. Its N.W. margin is about three-fourths of a mile from the base of the S.E. bounding mountain, and, from the end of Dividing Mountain, to a point S.W. of Fannettsburg, is well marked by a low ridge, on which that town is situated. The slate of the S.E. side of Path Valley meets that of the N.W., over the limestone, a short distance N.E. of the nook and spur in Tuscarora Mountain, which marks the entrance of the South-western anticlinal axis. The belt on the S.E. is traversed by the anticlinal axis ranging near the base of the mountain, between which and the limestone there is of course a synclinal axis—the same that receives the Levant sandstone of the Dividing Mountain to the N.E., and the short synclinal portion of the same formation which stands opposed to the end of that mountain in the spur of the Tuscarora Mountain, in the S.W. extremity of the valley.

In the S.W. end of Path Valley, the slate within the fifth or Western axis vanishes under the overlying slate-formation in the nook alluded to, but the slate within the eighth or South-eastern axis passes out of the mouth of the valley, being soon separated into two belts by the intrusion of the Matinal limestone N. of Loudon. Of these, the N.W. outcrop, dipping steeply N.W., stretches S.W. along the base of Little Cove Mountain, while the S.E., sweeping round Jordan's Knob, unites with the slate of Bear Valley.

Bear Valley and its Anticlinal Axis.—This narrow and nearly uninhabited valley lies between the S.E. bounding mountain of South Horse Valley, and the Blue or true Kittatinny Mountain. It extends from the State Road W. of Strasburg to a point E. of Loudon, terminating between Jordan's and Parnell's knobs. It is 11 or 12 miles in length, narrow and elevated towards the N.E., but wider and deeper between the knobs, and is barren and covered with forest.

The structure of Bear Valley is anticlinal, the Matinal slate appearing along its centre, and the Levant sandstone, with opposite dips, forming the bounding mountains. The anticlinal axis, originating in Shaeffer's Valley and passing along the back of the long spur which starts from the true Kittatinny Mountain at Three Square Hollow, crosses out at that place into the Cumberland Valley, ranges close along the base of the Kittatinny, N.W. of Roxbury and Strasburg, and traverses Bear Valley, out of which it runs S E. of Loudon, and becomes the axis of the middle of the three limestone belts in the W. portion of Franklin County.

Matinal Slate in Bear Valley.—The slate extends in a slender zone throughout Bear Valley, but is much covered with loose rocks. It widens between the knobs E. of Loudon, and, meeting with the belt of the same formation from Path Valley, it forms around Jordan's Knob the end of a synclinal trough, the axis of which is prolonged for a number of miles to the S.W. It also unites in a similar manner on the S.E. round Parnell's Knob with the belt at the S.E. base of the Blue or true Kittatinny Mountain.

AURORAL AND MATINAL ROCKS OF M^cCONNELLSBURG COVE.

This is a valley of elevation of the Auroral and Matinal rocks, situated in the S.E. part of Fulton County. The cultivated portion of it is about 18 miles in length, and its breadth varies from one to several miles. The S.E. side of the Cove is bounded by the Cove Mountain, the N.W. side by Little Scrub Ridge, Big Scrub Ridge, and Dickey's Mountain. Little Scrub Ridge bounds the N.E. end of the Cove, and ends nearly opposite to McConnellsburg. Six miles S.W. of its termination, and near Hunter's Mill, a knob rises called Lowrey's Knob, which is the termination of a mountain (Dickey's Mountain), bounding the N.W. side of the S.W. end of the Cove. Little Scrub Ridge and Dickey's Mountain, the extremities of which stand thus opposed to each other, though 6 miles apart, are continuations of the same belt of Levant sandstones, the portion between them being hidden in an immense dislocation, which extends for 12 miles along the N.W. side of the Cove. Big Scrub Ridge, which is considered as bounding the Cove where Little Scrub Ridge is absent at the fault, is a mountain of the Vespertine conglomerate, lying about one mile N.W. of the line of fault, the intermediate district being occupied with ridges of the Ponent red sandstone. See the Sections, illustrating the structure of McConnellsburg Cove and districts adjoining.

AURORAL LIMESTONE AND ANTICLINAL AXIS.

The Cove exhibits very little of that unevenness of surface which is favourable to the study of its strata.

The denuding currents seem to have acted with great energy, cutting down the limestone to the general level of the surrounding country. The streams are therefore more frequently on the surface and subterranean channels, are less numerous than in some other anticlinal valleys. The Auroral magnesian limestone alone forms the bed of the valley. It consists of alternating pale-blue magnesian limestone, and bluer purer limestones, occurring without any marked grouping. The layers bordering on the Matinal slate are black and often slaty. They are nearly destitute of fossils, but seem to be the Matinal shaly limestone.

Iron ore, though of little value, has been found in the limestone. It will be mentioned in another Section.

Anticlinal Axis.—The anticlinal axis which lifts the Auroral limestone is found near the middle of the Cove. In the North-eastern end the strata are slightly overturned on its North-western side, having a steep South-eastern dip 85°; on the other side the dip is only 25° S.E. Further South-westward towards McConnellsburg, the rocks on the N.W. side recover their position, but dip steeply North-westward. (See Section, fig. 53.) The axis passes through McConnellsburg, where the dips are 25° S.E., and 50° N.W. (See Section, fig. 54.)

Fig. 53.—Section 5 miles E. of McConnellsburg.

From this point it ranges about S. 23° E. for six or seven miles to where it is obliterated by the upheaving of the strata along the fault. This anticlinal line is not straight; it curves at a point between three and four miles N.E. of McConnellsburg, making a bend convex to the N.W. The limestone belt thus traversed by the axis is, in the part of the Cove N.E. of McConnellsburg, scarcely a mile in width; but opposite to that town it becomes, by a bend in Cove Mountain yet to be described, about two miles wide, and continues so for several miles, when it gradually contracts to its S.W. termination. It is finally saddled by slate in that portion of the Cove called The Corner, lying between Dickey's Mountain and the Cove Mountain, nine miles S.W. of McConnellsburg. The limestone lies in contact with Cadent strata throughout nearly all the distance between the extremities of Scrub Ridge and Lowrey's Knob along the fault, which I now proceed to describe.

FAULT ALONG THE NORTH-WEST SIDE OF THE COVE.

The rocks in and on both sides of Little Scrub Ridge, which commences in Sydney's Knob, at the Burnt Cabins, near the line of Huntingdon and Bedford counties, are, throughout the five or six miles of its course to the S.W. in their proper succession, but slightly overturned to the N.W., as in the anticlinal axis of the adjoining part of the Cove before described.

Further S.W., between six and seyen miles from Sydney's Knob, we find the commencement of a great fault. The adjoining limestone of the Cove begins to dip N.W.; becoming less and less inclined as it is traced S.W., the Matinal slate disappears, the Levant sandstones forming Little Scrub Ridge dip at an angle of 80° N.E., and the great body of the upper part of all the other Levant rocks, and the whole of the Pre-meridian limestone and Meridian sandstone, with a part of the Cadent rocks, are lost, and the Cadent strata dip 80° S.E. Opposite McConnellsburg the fissure is double, and for about four miles the Levant sandstones of Little Scrub Ridge lie unconformably between the Cadent rocks on the N.W. and the Auroral limestone on the S.E., in the attitude of an inserted wedge. The Levant white sandstone is much shivered and marked by slides. As we advance S.W. along this line to Little Scrub Ridge, the Auroral limestone takes a gentle dip to the N.W.

FIG. 54.—Section of Fault opposite McConnellsburg.

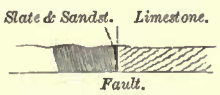


FIG. 55.—Fault 1 mile S.W. of end of L. Scrub Ridge.

FIG. 56.—Fault 1 mile N.E. of Hunter's Mill.

At the termination of Little Scrub Ridge we find the limestone dipping 30° North-westward, abutting against the Cadent rocks, dipping 80° S.E. (See Section, fig. 55.) Tracing the fault for several miles S.W., the limestone along its line becomes less inclined to the N.W., and the Levant white sandstone, in small masses, lies in the fissure at several points, forming low knolls. At Rankin's Clover Mill, four miles South-westward of the extremity of Little Scrub Ridge, the limestone along the fault dips S.E., forming a synclinal axis with the North-west-dipping strata of the anticlinal axis of the Cove. From this point S.W. for two miles to Hunter's Mill, the same relations continue. (See Section, fig. 56.) A short distance S.W. of Hunter's Mill the Levant sandstone emerges, and forms Lowrey's Knob, and on the N.W. flank of the knob the

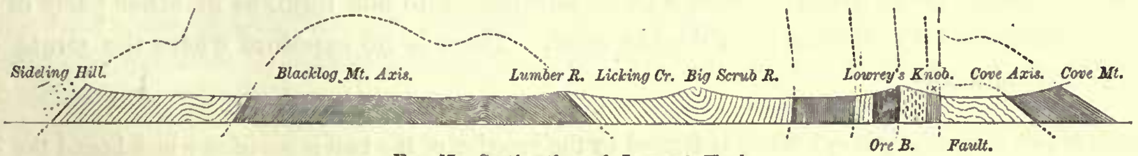


FIG. 57.—Section through Lowrey's Knob.

remaining Levant, Surgent, and Pre-meridian and Cadent strata all emerge in succession, but in a perpendicular attitude. The dislocation now becomes once more single, the S.E. or main fault continues on the S.E side of Lowrey's Knob, where a portion of the Matinal slate, much disturbed, with a vertical dip, lies in contact with the Auroral limestone, which here dips 30° S.E. A section made across the Cove at this point shows the limestone dipping uniformly S.E., the main anticlinal axis of the Cove ceasing, and the fault becoming the line of elevation for the remainder of the S.W. end of the Cove. (See Section, fig. 57.) Tracing the fault a mile and a half S.W. of Lowrey's Knob, it is found immediately at the base of Dickey's Mountain, the Auroral limestone dipping 30° S.E. in contact with the Matinal slate, which is perpendicular. (See Fig. 58.)

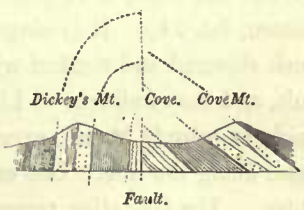


FIG. 58.—Fault, 1½ miles S.W. of Lowrey's Knob.

The limestone S.W. of the fault then begins to emerge, dipping steeply N.W., and the fault rights itself in the anticlinal axis of The Corner with a S.E. dip of 30°, and a N.W. dip of 60° or 70°. (See Fig. 59.)

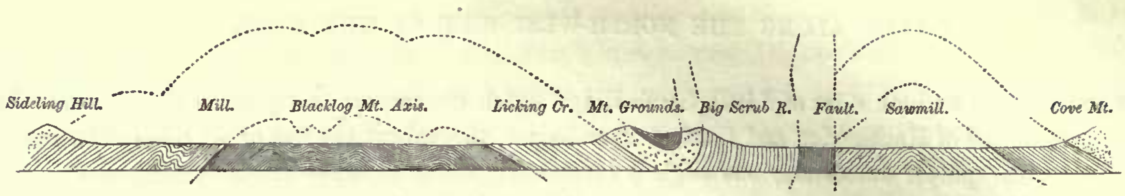


FIG. 59.—Section S.W. of Lewrey's Knob.

MATINAL SLATES OF THE COVE.

This group of rocks forms two broad belts in the Cove. Wherever exposed, it has its usual characters. It occupies the N.E. end of the Cove for several miles, and is traversed by the anticlinal axis, until, the limestone appearing, the slate divides into two belts. That N.W. of the axis stretches along the S.E. base of Little Scrub Ridge, with a perpendicular dip, until it is lost in the fault several miles N.E. of McConnellsburg. The continuation of the same tract shows itself nine or ten miles S.W. at Lowrey's Knob, where the formation partially emerges. Hanover ore-bank is on the slate at that point. Further S.W. the whole of it gradually emerges, and forms the S.E flank of Dickey's Mountain, reaching high up its slope. It meets the S.E belt several miles from Hunter's Mill, folding over the axis, which is here a continuation of the fault, as before described.

The belt which borders the Cove on the S.E. is nearly half a mile wide, not reaching very far up the mountain. It forms a gentle slope at its base. The strata dip uniformly about 30° S.E. Opposite McConnellsburg it sweeps to the South where the Cove Mountain bends, and then again resumes its former bearing, which is S. 30° W. Traced S.W. it unites with the belt before described, and the S.W. end of the Cove is entirely occupied with slate for several miles. It is there much covered with loose rocks from the mountains. The iron ore of the slate will be noticed in a separate section.

LEVANT SANDSTONES OF THE COVE MOUNTAINS.

This group does not, in the district before us, retain its usual triple character, the middle and softer member being absent. Hence these sandstones do not form, as in other parts of the State, mountains with a terrace or a double crest. There is no exposure where the strata can be examined minutely.

Little Scrub Ridge.—Sydney's Knob is formed by the junction of the two mountains which bound the N.E. end of the Cove. The North-west one is Little Scrub Ridge. This toward its North-east end is of the usual height of the mountains of the Levant sandstones, but traced S.W., it becomes a low ridge, with an undulating summit ranging about S. 30° W. The strata in the N.E. end are slightly overtilted for some distance, but traced S.W. to the fault, it is probable that only the superior harder white sandstone remains in the fissure. (See Section, fig. 54.) It is singular that these strata dip with much regularity 80° S.E. The sandstone is very much shivered and marked with parallel striæ, caused by sliding upon itself. The formation disappears in the fault, and the sandstone of Little Scrub Ridge ends N.W. of McConnellsburg, and for six miles S.W. to Lowrey's Knob, is entirely buried, except that a few isolated masses of white shivered sandstone, 30 or 40 feet thick, are found along the line. One of these may be seen near Stoke's Saw-mill, two miles from the end of Little Scrub Ridge. The formation reappears to form Lowrey's Knob, where its strata dip 80° N.W. Lowrey's Knob is separated from Dickey's Mountain, a continuation of the same strata, merely by a gap.

Dickey's Mountain.—This is between five and six miles long, extending nearly to the State-line, where it ends by uniting with the Cove Mountain on the anticlinal axis, the two enclosing between them the narrow extremity of the Cove called The Corner. Dickey's Mountain is of the usual height of the ridges of the Levant sandstones. It has a straight crest and even flanks. The formation is perpendicular, and presents its ordinary aspect. Loose rocks cover the surface, but not to the same extent as observed in other mountains of similar construction.

Cove Mountain.—The mountain bounding the McConnellsburg Cove on the S.E. receives this name. Commencing in Sydney's Knob, it stretches nearly in a straight line S. 30° W., until it reaches a point S.E. of McConnellsburg, including between it and the Western continuation of the Tuscarora Mountain a slender synclinal valley, which terminates by gradually ascending as the mountains coalesce. The Cove Mountain then makes a sweep to the S. Up the Western side of the curve the Chambersburg Turnpike ascends. By this curve the Cove is considerably widened. The mountain then, resuming its original bearing, curves W. to unite with Dickey's Mountain, and shuts in the S.W. end of the Cove. The mountain is high, and its rocks dip uniformly about 30° S.E., and its flanks are unbroken, and covered with fields of loose stone.

Terminating against the Eastern side of the remarkable curve in Cove Mountain, S.E. of McConnellsburg, there is an anticlinal axis in the Levant sandstones which extends from the N.W. side of Path Valley. The other anticlinal axis, that of the S.E. side of the same valley, passes into the valley of Loudon and Mercersburg, and extends S.W. between those towns and the Little Cove Mountain. Between these two axes lies the synclinal trough of the Little Cove. A mountain-knob of Levant sandstones terminates the Little Cove at a point two miles N.E. of Loudon, projecting forward into Path Valley, W. of Old Mount Pleasant Furnace. The South-east-dipping Levant sandstones of this basin prolonged S.W. from the knob, and inclined at an angle of 40°, unite almost immediately with the same strata composing Tuscarora Mountain, which dip N.W. over the N.W. anticlinal axis, and the two form a very high and broad summit, which is N. of the line of the Chambersburg Turnpike. This anticlinal mountain, two miles long, merges into the Cove Mountain, the little valley N.W. of it becomes obliterated, and the rocks all assume the South-eastern dip.

The synclinal basin which we have described as the Little Cove is bounded by the Levant sandstone, and the S.E. belt of this extends S.W., under the name of the Little Cove Mountain.

Little Cove Mountain.—This name properly applies to the continuous mountain N.W. of Loudon and Mercersburg, separating the Great Valley from the Little Cove. Between the Mercersburg and the Chambersburg turnpikes it is scarcely distinct from the Cove Mountain, denudation not having scooped the basin here to any great extent. The rocks forming the Little Mountain have a perpendicular dip, and as a consequence the mountain is low, the denuding floods having encountered less resistance than if the dip had been less steep. This mountain is cut by three gaps: one near its N.E. origin, through which the Chambersburg Turnpike passes; another about a mile further S.W.; and a third four miles still further S.W., through which the Mercersburg Turnpike runs, and where a considerable stream has exit. Thence to Maryland the mountain is uniform, carrying a regular crest with a slight curvature.

The Levant sandstones crop out on its summit, and the Surgent slates ascend high on its N.W. flank, while the Matinal slates lie at its S.E. base.

The curve in the Cove Mountain above noticed is owing to the dying away of the N.W. anticlinal axis of Path Valley.

CHAPTER II.

LEVANT AND SURGENT AND SCALENT ROCKS OF PERRY AND FRANKLIN COUNTIES.

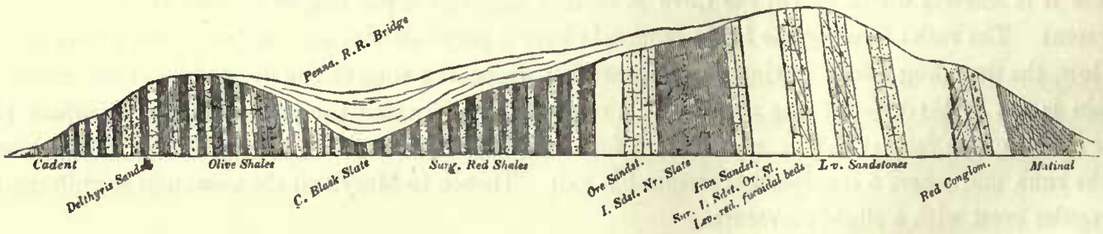
LEVANT SERIES.

COMPOSITION.

THE character of the Levant white, red, and grey sandstones could not be minutely studied at any point observed. Red shales and sandstones constitute the middle member of the group, while reddish conglomerate and grey sandstone form the lower. This latter produces an indistinct terrace on the N.W. side of North Horse Valley, but nowhere else is the evenness of the surface affected by it. The thickness of these three rocks in the Kittatinny Mountain at the Susquehanna does not exceed 100 feet, of which the upper or white sandstone composes perhaps one-half. There is a perceptible augmentation of thickness visible as we trace them S.W., and a still more rapid increase when we find them rising to the surface in their outcrops further N.W.

The chief member is the Levant white sandstone, the middle formation, the Levant red sandstone being either wholly absent or very thin. The gradual expansion of the group arises chiefly from augmentation of the Lower or Levant grey sandstone, and from the introduction of the Levant red sandstone.

FIG. 60.—Section of Kittatinny Mountain, E. side of the Susquehanna River.



SURGENT AND SCALENT SERIES.

COMPOSITION.

Surgent Slates and Ore Shales.—In the district under review the lower and middle divisions of the Surgent Series include, as usual, six members—the Surgent lower slate, Surgent iron-sandstone, Surgent upper slate, Surgent lower ore-shales, Surgent ore-sandstone, and Surgent upper ore-shales. But some of these have not the expanded thickness in which we shall hereafter meet them as they outcrop further to the N.W.

The *Surgent Lower or Older Slate* has a thickness of from 150 to 200 feet. It consists of grey, dull olive, and obscurely claret-coloured shaly slate, which is apt to acquire by exposure a buff or yellow tint. In it are a few thin layers of a grey or snuff-coloured calcareous sandstone. Its chief fossil is the little Clinton fucoid, the *Buthotrephis gracilis.*

Surgent Iron Sandstone.—This rock has a thickness in the Kittatinny Mountain, at the Susquehanna, of at least 80 feet, but it grows less towards the N.W. It appears to include little else than deep red or brown sandstone; the interstratified red shale, seen in it at Danville and elsewhere, being very nearly absent, though occasional small lumps or pebbles of that material contribute to compose the sandstone. It contains a few organic remains.

Surgent Upper or Newer Slates.—This member, under its usual form of a dingy, olive-coloured shaly slate, has a thickness of about 100 feet.

Surgent Lower or Older Ore Shale.—In the district before us this stratum has been but imperfectly developed, its thickness not exceeding probably 100 to 150 feet. The calcareous fossiliferous layers which generally characterise it, and which occur even at Mifflintown, are very little seen in Perry County. In some neighbourhoods its fossiliferous iron-ore is sufficiently thick to be recognisable.

Surgent Ore Sandstone.—This useful guide to the iron ores is present in the district, in the form of a close-grained, hard, white sandstone, containing grey, flaggy, and ferruginous layers. The thickness of the rock is about 15 feet. In the S.E. part of the county the fossiliferous ore lies below this rock, while in the N.W. part the ore is above it, there being, as in so many other districts of the country, two beds alternately expanded. They are both found closely adjacent to the sandstone.

Surgent Upper or Newer Ore Shale.—A calcareous olive slaty shale, including some beds of limestone. It weathers of a buff colour, occupies the usual position above the ore sandstone, and, as already intimated, contains in some places, in its lowest part, the fossiliferous iron-ore. The thickness of the mass is inconsiderable on the S.E. side of the district, being from 30 to 50 feet, but on the N.W it amounts to 150.

The upper division of the Surgent series embraces the calcareous red shales or marls—

Surgent Red Shale.—This red shale in Perry County is, when compared with most of the other strata, of great thickness, measuring at the Susquehanna as much as 400 feet. It furnishes much of the best soil of the country, producing, in some of the better-cultivated valleys, noble harvests of grain.

Scalent Variegated Marls.—This member of the Scalent series begins to appear in some force as we approach the Tuscarora axis; but its thickness, which is probably not more than 100 feet, has not been ascertained. It is hardly to be seen at the Susquehanna Gap.

Scalent Grey Marls.—These rocks, consisting of grey, ashy, greenish, and bluish calcareous shales, acquire in the North-eastern side of the district near the Tuscarora Mountain a thickness of at least 600 feet; and as they are altogether wanting along the base of the Kittatinny Mountain, we may infer that in the central belt of the county the thickness is from 200 to 300 feet. In the upper part of the mass, near the bottom of the Scalent limestone, there is a bed of argillaceous sandstone, in layers of various colours, dull red, grey, white, and greenish. This rock, which breaks up into small rectangular fragments, has a total thickness of only 8 or 10 feet, and yet, owing to its great superior hardness to the underlying marls, it generally forms a decided feature in the surface, occupying a low ridge, by which it and the strata adjoining it may easily be recognised.

These two lower groups of the Scalent strata present, in the district between the Kittatinny and Tuscarora mountains, a progressive and striking expansion towards the N.W. Along the

S.E. outcrop of the series in the first-named ridge, they are not, at least at the Susquehanna River, even recognisable ; but in the immediate neighbourhood of Millerstown they attain a thickness of probably from 600 to 800 feet, the grey marls especially undergoing a rapid augmentation.

Scalent Limestone.—Absent altogether at the Kittatinny Mountain, this formation rises in its successive outcrops along the central and northern belts of the county, in sufficient thickness to confer on it considerable interest, especially as it furnishes in some of its beds a lime admirably suitable for agricultural use. It would seem, however, to fluctuate considerably and rapidly in its dimensions. Thus in the vicinity of Millerstown it is apparently not more than 30 feet thick, whereas near the Susquehanna, 6 miles above Liverpool, on the Tuscarora axis, it has a thickness of nearly 200 feet. It is readily distinguishable from the more fossiliferous Premeridian limestone, which rests upon it, by its having few organic remains, except the *Cytherina alta*, by which it is well characterised.

LEVANT SERIES.

GEOGRAPHICAL DISTRIBUTION.

Levant Sandstones, Tuscarora Mountain.—The mountain-chain separating Juniata and Huntingdon from Perry and Franklin counties is called the Tuscarora Mountain. There are, however, two distinct mountains confounded under this name, differing in their geological structure. They are not in a line, but pass each other, so that the W. end of Liberty Valley lies between their extremities. Of these mountains the North-eastern is anticlinal, and the South-western monoclinal, being elevated with a N.W. inclination by the axis of Horse and Path valleys.

North-eastern Tuscarora Mountain and Anticlinal Axis.—The anticlinal axis of Tuscarora Mountain rises in the Vergent slates a mile or more from the Susquehanna, and passes 2 miles N.W. of Liverpool. It extends centrally through Pfout's Valley to the N.E. end of the mountain. The axis is prolonged 12 or 13 miles before the South-western termination of the mountain, in the Surgent slates and shales and higher rocks, terminating several miles W. of Waterloo. In this part of its course it is near the N.W. base of the Monoclinal Tuscarora Mountain, and passes S.E. of Waterford, and close by Waterloo.

The line of elevation thus traced is 47 miles in length. It is gently curved, changing its bearing from S. 78° W. to S. 45° W., or 33°.

One end of the mountain, formed by this axis, is E. of the Juniata above Millerstown, and the other, $2\frac{1}{2}$ miles E. of Waterford. Between these the distance is 24 miles. The crest of the mountain rises very gradually, and sinks in the same manner. The summit is broad and rounded. There are two trivial depressions near its South-western end, but its outline is almost unbroken. The *Run Gap* is a deep gorge in the S.E. side of the mountain near Ickesburg, through which a stream flows out of a short valley or hollow over the axis. There are two ravines on the N.W. side, in the neighbourhood of this valley, on the mountain.

Laurel Run passes from Liberty Valley through a gap near the West end of the mountain, which is there very low.

The Levant white sandstone saddles this mountain in a very regular and unbroken anticlinal flexure of the normal type. In one place only is there a tendency to the formation of a valley over the axis. It is at the Run Gap, where the next lower rock, the Levant red sandstone, is revealed by denudation for a length of nearly 2 miles, the relative softness of this rock causing the valley. The strata on the North-western side of the mountain dip 70° or 80° N.W., and those on the S.E. from 40° to 50° to the S.E. A portion of the Levant white sandstone is left on the East side of the Juniata above Millerstown, the river passing, as it were, across the point of the mountain, the flanks of which are mantled by the Surgent slates which fold round its extremities.

Mountain South-east of Liberty Valley.—The N.E. portion of Liberty Valley is bounded on the S.E. by the Conecocheague Mountain, and on the N.W. by a mountain rising in the valley, and extending South-westward, under the name of Tuscarora Mountain. Both these mountains are at their origin of anticlinal structure, the Conecocheague stretching 3 or 4 miles further North-eastward than the Tuscarora. They form between them a deep hollow or narrow valley. Nearly opposite the same point, at the N.E. end of Horse Valley, both of these mountains become cleft over their axis, and the strata between them dipping towards a synclinal line, form a high knob which stands forward into the N.E. end of Horse Valley, while monoclinal ridges extending on S.W., form the barriers enclosing that valley.

The knob which rises in Liberty Valley is formed by the Levant white sandstone, elevated along the first anticlinal axis of Sherman's Valley. It is broad and rounded. Its crest rises gradually to its greatest elevation between 2 and 3 miles from its origin, beyond which it divides over the axis, and the South-east-dipping strata terminate in the synclinal knob, as already mentioned. The North-west-dipping strata, stretching for 35 miles to the S.W., bound Horse and Path valleys, and constitute the S.W. Tuscarora Mountain.

Monoclinal Tuscarora Mountain.—This mountain, from its origin in Liberty Valley to a point opposite Fannettsburg, a distance of 28 miles, is exceedingly uniform, curving gently to the S. There are two irregularities in its curve, one E. of Waterloo Gap, and another a few miles N.E. of Fannettsburg, attributable to the dying away of the Horse Valley axis in the valley E. of it. The outline of the mountain is very slightly undulated, and its crest acute. It is cut by two water-gaps, one near Waterford, and another 8½ miles E. of Waterloo.

The N.W. flank is mostly an even slope, the Surgent shales extending high upon it.

The South-eastern slope in Horse Valley is marked by an indistinct terrace cut into ravines at intervals, which becomes imperceptible in Path Valley.

West of Fannettsburg the mountain trends somewhat more to the W. Its outline is more irregular, and its S.E. slope is marked by a terrace extending from the State road a mile or two S.W., when the slope has again an even surface. This terrace is broken by several gorges. It is produced by fractured strata connected with the Path Valley fault. The S.W. flank of the mountain is also broken where the State road crosses it from Fannettsburg. This is connected with the Surgent iron-sandstone, and will be noticed in a subsequent Chapter. The Tuscarora Mountain is cut by a third gap, 6 miles S.W. of Fannettsburg, and extends from the gap about 3 miles S.W., when it unites in the broad mountain mass known under the name of Cove Mountain.

The Levant sandstones in the Tuscarora Mountain, from Liberty Valley to a point N.W. of Fannettsburg, have uniformly a steep N.W. inclination from 60° to 80°. In Horse Valley, the inferior stratum, the Levant grey sandstone, by offering a greater resistance to denudation than the Levant red sandstone above it, has produced a broken terrace which vanishes in Path Valley. Where the State road crosses the mountain from Fannettsburg, the sandstone, as it is broken by the fault, has been described. The rock in the crest of the mountain has there a gentle dip N.W., but it is again steeper to the S.W. of that point. The Levant sandstones dip 50° N.W. at Cowan's Gap, 6 miles S.W. of Fannettsburg. Tracing the rocks S.W. of the Gap for 2½ miles, they fold over the *first axis*, uniting with the strata which there commence to occupy the synclinal axis to the S.E. From thence S.W. for 4 miles there ranges a high mountain of anticlinal form, terminating in the S.E. bounding mountain of the Cove, opposite McConnellstown.

The fractured strata of the Levant sandstones, connected with the Fault towards its S.W. end, have been described already.

Conecocheague Mountain—Second Anticlinal Axis.—This mountain bounds the Western portion of Sherman's Valley on the N.W., separating it from Liberty Valley and North Horse Valley. The portion of the mountain between it and the former valley is of anticlinal structure. It extends from Linn's Mill to the head of Horse Valley, a distance of 8 or 9 miles, having a straight outline and rounded summit, except towards the N.E. extremity, which is more ragged and lower, being composed of the Surgent iron-sandstone and Surgent slate. A notch, 3 miles from the N.E. end, is called Conecocheague Gap. The rocks dip 50° S.E. and 60° N.W. The Surgent iron-sandstones and Surgent slates repose high on the flanks of the mountain, the Levant white sandstone constituting the crest.

In the N.E. end of the Horse Valley, N. of Germantown, the Conecocheague Mountain is cleft over the axis. The South-east-dipping strata are prolonged S.W., forming the proper continuation of the mountain. The sandstone N.W. of the axis unites, as before described, in producing the high synclinal knob in the N.E. end of Horse Valley. This union of the mountain axes is, in the neighbourhood, called the Locking of the Mountains.

The valley between the mountains is narrow and uninhabited, gradually rising into a circumscribed table-land on the top of the synclinal knob.

That part of Conecocheague Mountain which is monoclinal, bounds North Horse Valley on the S.E., and has a straight outline and gentle curve S. Its flanks have an even surface, and no traces of a terrace or bench are found upon it in Horse Valley, in which feature it differs from the mountain which fronts it on the N.W. side of the valley. It ends in the synclinal knob of Round Top South of Concord. The crest of this mountain, like all the great monoclinal ridges of the district, is composed of the Levant white sandstone.

Levant Sandstone in the Knobs in the South-west End of Sherman's Valley.—There are three anticlinal knobs standing out into the S.W. end of Sherman's Valley, between the Conecocheague and Bower's Mountains. Of these the most Western is called Round Top.

Round Top (Anticlinal).—There are two knobs receiving this name—one, of synclinal structure, looking upon Path Valley, and the other—that under consideration—of anticlinal structure. This rises rather abruptly 4½ miles S.W. of Germantown, consisting of the Levant white sandstone, elevated by the fifth anticlinal axis of Sherman's Valley. It is broad and rounded, and about 2 miles from its origin it forks, enclosing the North-eastern end of Burns's Valley. The formation, N.W. of the anticlinal line, extends 2 miles S.W., uniting with the Conecocheague Mountain in forming the synclinal Round Top of Path Valley bounding Burns's Valley on the S.W. There is a narrow barren valley between the Round Top and Conecocheague Mountain. It is synclinal, and will be noticed when tracing the Surgent slates. The Levant sandstone, separated on the S.E. of the anticlinal line of Round Top, stretches S.W. round Burns's Valley, and unites with a South-west-dipping belt of the next knob to the S.E., and is prolonged S.W. under the name of the Dividing Mountain. From its separation from the Round Top to its union in the Dividing Mountain, it forms a curve or synclinal flexure, which is to be attributed to the sixth anticlinal axis which terminates at that point.

The Rising Mountain.—The middle knob of the South-western end of Sherman's Valley is called the Rising Mountain. This consists of the Levant white sandstone uplifted along the seventh anticlinal axis. This knob commences 2 miles S.W. of Germantown in a line with Buck Ridge, having the same axis, its crest line ascending very gradually to its most elevated point, 3½ miles from its origin, where the ridge is cleft over the axis and separated into two crests by a narrow and elevated valley or ravine, which opens into the N. corner of Amberson's Valley. The crest to the N.W. of the axis unites, after a course of about 2 miles, with the South-east-dipping strata of Round Top, to form the Dividing Mountain.

Levant Sandstones—Dividing Mountain.—This separates Path Valley from Amberson's Valley, and is nearly 9 miles in length, ending abruptly 5 miles N.E. of Fannettsburg. It is straight, and has one depression a little more than a mile from its S.W. extremity. Its slopes are even, steep towards the summit, and very gentle towards the base. This mountain is synclinal, the Levant white sandstone composing its crest, which is sharp, and the Levant red sandstone and Levant grey sandstone outcropping high on its flanks. Its strata dip 30° S.E. and 40° N.W.

The synclinal spur of the Levant sandstones in the S.W. end of Path Valley corresponds to the extremity of the Dividing Mountain, being in the same synclinal axis from which, along the intermediate space, the sandstones have been removed, from having been uplifted high above the general plane of denudation opposite the highest or culminating part of the main Path Valley anticlinal axis.

A short and uncultivated valley of the Surgent slates and iron sandstone, opening into Sherman's Valley, exists between the Round Top and the Rising Mountain, and is traversed by the sixth anticlinal axis, which, flattening out, produces the bend in the mountain, enclosing it on the S.W.

The Levant sandstones, separated on the S.E. of the axis of Rising Mountain, extend S.W. for 1½ miles, when they unite with a N.N.W.-dipping outcrop to form a synclinal knob in the N. corner of Amberson's Valley.

Amberson's Knob is the third in the South-western extremity of Sherman's Valley, and consists, like the rest, of the Levant white sandstone, elevated by the eighth anticlinal axis, being, in fact, the exact counterpart of the Rising Mountain—both originating opposite the same point, and rising in the same gradual manner. About 2½ miles from its N.E. end it is divided, a narrow valley descending between the two crests into Amberson's Valley, marking the position of the axis. The N.W. crest extends S.W. for 2 or more miles, and terminates by meeting the S.E. crest of Rising Mountain, and forming a synclinal knob—the most N.W. of the two which occupy the N.E. end of Amberson's Valley.

The S.E. division of Amberson's Knob, extending 2 miles S.W., unites with the North-west-dipping belt of the same formation composing Bower's Mountain, and forms a synclinal knob which is the South-eastern of the two in the N.E. end of Amberson's Valley; but these synclinal knobs, thus formed, need no further detailed description.

A narrow synclinal valley, holding only the Surgent older or yellow slate and iron sandstone, several miles in length, lies between Amberson's Knob and the Rising Mountain. It is of course closed to the S.W., but opens into Sherman's Valley, and is entirely uninhabited. There is another little valley, precisely similar in character, which lies between Amberson's Knob and Bower's Mountain, but neither of them is distinguished by a name.

Levant Sandstones—Bower's Mountain.—Bower's Mountain is between Sherman's and Shaeffer's valleys, and is the Levant white sandstone, elevated by the thirteenth anticlinal axis. Its N.W. extremity is about 1½ miles W. of Landisburg, from whence it extends S.W. for 9 miles, with a slight curve to the S., beyond which there is a short bend to the W., and there again the mountain resumes its original bearing. This irregular curving is S.E. of Germantown, and connected with the rising of an axis in Shaeffer's Valley opposite the bend.

Bower's Mountain, from its origin to a point S.E. of Germantown, is completely anticlinal, having a flat summit and a straight outline, except that its N.E. extremity, being composed of the Surgent iron-sandstone, is lower, and has a rather broken crest line for several miles, as will be noticed more particularly in describing the Surgent slate group. The flanks of the mountain are slightly furrowed at intervals, and two deep gorges exist on the N.W. side at the irregular curve. The mass of the mountain is composed of the Levant white sandstone, flanked with the Surgent slate group, the whole dipping steeply in both directions.

Immediately S.W. of the irregular flexure, Bower's Mountain becomes fissured over the axis, and a narrow elevated valley is formed, which, extending S.W. for 7 miles, gradually descends and opens into Amberson's Valley between the (false) Kittatinny Mountain and the S.E. synclinal knob at which the mountain separates into two crests. The N.W. crest is prolonged until it meets the South-east-dipping belt of Amberson's Knob, and the two belts terminate by forming the S.E. knob of the N.E. end of Amberson's Valley. The N.W. crest of Bower's Mountain is cut by two gaps a mile apart. Through the more N.E. of these the Germantown and Shippensburg road passes.

The South-east Division of Bower's Mountain.—This extends nearly in a straight line with remarkable regularity for 12 or 13 miles S.W. It passes along the S.E. side of Amberson's Valley, where it receives the name of Kittatinny Mountain, and, extending S.W., it terminates in a knob in the S.W. side of South Horse Valley, 3 miles W. of Roxbury. It has an unbroken outline and even height, and throughout its whole course forms the N.W. boundary of a long slender valley, which is truly the N.E. prolongation of South Horse Valley, although it receives no name.

This mountain is composed of the Levant sandstones with a S.E. dip, and ends by meeting over the axis the oppositely-inclined strata. A little short of this point it is cut by a gap. It is the first mountain beyond the Blue or true Kittatinny Mountain at Roxbury.

Levant Sandstone, Clark Knob (of Amberson Valley).—There are two knobs which receive this name; one is near Strasburg, and the other on the S. side of Amberson Valley. Clark Knob stands opposed to the knob formed by the union of Bower Mountain and Amberson Knob, and between 4 and 5 miles S.W. of it. It is composed of the Levant sandstones in the same synclinal axis which, between the knobs, has been removed. Clark Knob, traced to the S.W., is separated into two crests by a slender elevated valley, holding the Surgent older slates. This opens into South Horse Valley about 4 miles S.W. of the knob. The South-eastern crest, 3 or more miles from Clark Knob, meets the South-east-dipping strata, which we have shown to be prolonged from Bower Mountain, and forms the anticlinal knob in Horse Valley before mentioned. This closing of the axis takes place immediately S.W. of the State Road, which passes from Roxbury to Path Valley. The mountains are both cut by gaps just before they unite—a very unusual feature, and through these the road winds.

The Western division of Clark Knob, extending S.W., becomes the main S.E. bounding mountain of Path Valley, separating it from South Horse Valley.

This mountain, from Clark Knob to a point 6 miles S.W. of Fannettsburg, 14 miles distant, is nearly straight, with a crest somewhat undulated. Beyond that point it bends towards the S., and unites with the S.E. bounding mountain of Horse Valley, forming Jordan's Knob, near Loudon. Its crest is composed of the Levant sandstones, apparently of diminished thickness, having a S.E. dip. The Surgent slates mount high upon its flank in South Horse Valley, and the Matinal slates ascend it on the Path Valley side.

Levant Sandstones of the Kittatinny Mountain.—We shall proceed to trace this mountain from the Susquehanna, and regard the two knobs S. of Landisburg as mere inflections, or re-entering angles, produced by the passage of anticlinal axes through the mountain, from the lower formations of the Cumberland Valley.

Bounding the great Appalachian Valley, here called the Cumberland Valley, in Cumberland and Franklin counties, from the Susquehanna to Parnell's Knob, this mountain extends for 60 miles in a general curve, changing its bearing from S. 80° W. to S. 35° W., or 45°. It presents, however, many irregularities, which will be noticed.

Levant Sandstones in the Kittatinny Mountain, from the Susquehanna to the Spur south of McClure's Gap.—From the Susquehanna Water-Gap the mountain extends in nearly a straight direction for 20 miles, with a bearing about S. 82° W. In this part of its course it has uniform and peculiar features. Towards the Susquehanna its crest is sharper, and has a more unbroken outline; but to the S.W. it is remarkably undulating, and has a rounded summit, in many places cultivated. Some of these undulations, or notches, are rather deep; such are Sterret, Long, and Waggoner gaps. The S.E. slope of the mountain is steepest towards the summit, and gentlest at the base. The S.W. slope terminates at the base of a ridge composed of the Cadent sandstone, and forms with it a slender valley called Polecat Valley.

The strata in the portion of the Blue Mountain here described are perpendicular, and at the Susquehanna, and for a few miles S.W., inverted, the dip being 70° and 80° S. The Southern brow and slope only are occupied by the Levant grey sandstones, which here are hardly 10 feet thick, whereas the actual summit and Northern slope consist of the Levant white sandstone and Surgent slate group, the Surgent iron-sandstone outcropping along the true crest, its great relative thickness, 80 feet, conspiring with its excessive hardness, and especially with the overturn of the dip, to produce this anomalous condition. (See Section, Fig. 60.)

Spur or Angle of Blue Mountain south of McClure's Gap.—Twenty miles S.W. of the river the Blue Mountain, as seen from the Cumberland Valley, makes a sudden curve or fold towards the N., and then again assumes its W. bearing. This is produced by the nineteenth, or most southern of the Sherman's Valley anticlinal axes, which passes out into the Cumberland Valley south of McClure's Gap. The mode in which this feature is produced may be thus described: The anticlinal axis elevates the Levant white sandstone N.W. of Oak Grove Furnace, producing Welche's Knob. This is the most S.W. of two knobs which stand forward into Sherman's Valley, S. of Landisburg. Welche's Knob, rising rapidly to a great elevation, is trenched over the axis, and the South-east-dipping strata fold round to meet the main mountain, producing the angle which has been described. This encloses on its N.E. side a little nook, called in the neighbourhood Green's Valley.

The North-west-dipping strata of Welche's Knob, extending S.W., bound Kennedy's Valley on the S.E., and terminate in the spur S. of Dublin Hollow.

Spur of the Kittatinny Mountain south of Dublin Hollow.—The seventeenth anticlinal axis of Sherman's Valley elevates the Levant sandstones to form a knob S. of Landisburg, called the Pilot Hill. This rises rather abruptly, and its N.E. portion is composed of the Surgent iron-sandstone, the interval between this rock and the Levant white sandstone being marked by a step or offset on the slope of the mountain, caused by the softer Surgent older slate.

The Pilot Hill, $2\frac{1}{2}$ miles from its N.E. extremity forks, and its anticlinal axis lifting the Matinal slate, passes out into the Dublin Hollow. The N.W. division of Pilot Hill is prolonged S.W., as the main Kittatinny Mountain, bounding Shaeffer's Valley on the S.E. The S.E. division makes a gentle curve S. five miles from the separation, and unites with the North-west-dipping strata, extending from Welche's Knob, forming a spur of the Blue Mountain, which encloses Kennedy's Valley. The narrow valley which is formed between the spur and the main mountain, opening out into the Cumberland Valley, is called Dublin Hollow, and is between 5 and 6 miles in length, the mountain slopes meeting in its centre. It is cultivated toward the S.W. end.

The mountain enclosing the valley is therefore synclinal, embracing the Surgent slates in the trough of Kennedy's Valley. The outside slopes are smooth, the Matinal slate reaching high up, but those bounding Kennedy's Valley exhibit protuberances caused by the Surgent iron-sandstone, and will be noticed in the sequel. The crest outline of the mountain is slightly undulated. A notch immediately S.W. of the point where Welche's Knob separates, is called McClure's Pass.

Kittatinny Mountain, South-east of Shaeffer's Valley.—The South-western division of Pilot Hill extends S.W., with a gentle curve separating Shaeffer's Valley from Dublin Hollow and the Cumberland Valley. It has an undulating summit, and a considerable notch, near the N.E. end of Dublin Hollow, through which a road passes, is called Dublin Gap. The mountain is very uniform, being composed of the Levant sandstones, with a N.W. dip. It has a sharp crest and even slope on the S.E., but is less smooth on the Shaeffer's Valley side. At the S.W. side of Shaeffer's Valley new conditions occur, next to be described.

Short Axis in Levant White Sandstone between Bower's Mountain and the Blue Mountain in the South-west end of Shaeffer's Valley.—In the S.W. extremity of Shaeffer's Valley, between 11 and 12 miles from Landisburg, the Levant white sandstone is thrown up by an axis forming a mountain, which separates that valley into two branches. This mountain rises opposite the irregular curve in Bower's Mountain, and nearer to that than to the Blue Mountain. The narrow or N.W. division of Shaeffer's Valley extends as a slender elevated valley for a number of miles S.W., opening into South Horse Valley.

The S.E. branch of Shaeffer's Valley gradually becomes elevated into the table-land on the top of the Blue Mountain, N.E. of the Three Square Hollow. This arises in the following manner:—

The short anticlinal axis, extending S.W. for 4 or 5 miles, lifts the Levant white sandstone until this separates over the axis, where it passes out into the great valley; the South-east-dipping strata, uniting with the Blue Mountain Proper, form the table-land before mentioned, which is a synclinal mass of the sandstone, with probably a wave or wrinkle in the dip, and this table-land becomes narrower by a curve in the Blue Mountain towards the W. until it ends, and the synclinal knob ceases a short distance S.W. of the Three Square Hollow, and the North-west-dipping strata from the axis range on S.W. as the main Blue Mountain.

The Three Square Hollow is a deep gorge cut into the synclinal table-land at its S.W. end. It has a triangular form, whence probably its name. S.W. of the Three Square Hollow the Blue Mountain has a broad and elevated summit, which is a continuation of the summit of the Short Mountain containing the axis.

The Blue Mountain, as seen from the Cumberland Valley, makes several considerable curves opposite the axis now described. Bounding Shaeffer's Valley, it ranges about S. 50° W., then curves towards the W. to Three Square Hollow, beyond which it resumes its original bearing for a mile or two, when it again sweeps towards the W. for several miles, and finally returns to its former bearing, passing N.W. of Roxbury.

Levant Sandstone in the Kittatinny or Blue Mountain North-west of Roxbury and Strasburg.—From the flexure last mentioned, which is 4 miles N.E. of Roxbury, the Blue Mountain extends to a point W. of Strasburg in nearly a straight line. Its outline is regular, and it is cut by a water-gap W. of Roxbury, through which Horse Valley is drained. Its slopes are even, and it has a sharp summit. It separates South Horse Valley, and its slender prolongation into Shaeffer's Valley, from the Cumberland Valley. At the Roxbury Gap the strata dip 45° N.W.

Immediately W. of Strasburg the Levant sandstones form a synclinal double mountain, separated by Bear Valley from the mountain crest, which is truly a continuation of the Blue Mountain, as it extends N. of Strasburg and Roxbury.

The S.E. bounding mountain of Horse Valley is somewhat lower than the synclinal mountain S.E. of it. It has a level crest and unbroken slopes. It is cut by three gaps 1 mile or more apart, and through the most N.E. of these, which is a mere notch, the road from Fannettsburg passes. It terminates to the S.W. by uniting with the mountain between Horse and Path valleys, to form Jordan's Knob, N.E. of Loudon. Its rocks have a steep N.W. dip, the Levant white sandstone being in the summit.

Jordan's Knob is elevated and gashed by one or two ravines. It is synclinal, and closes the S.W. extremity of Horse Valley. The distance from the gap W. of Strasburg to Jordan's Knob is between 10 and 11 miles. Horse Valley will be described in connection with the Surgent slate and shales.

Levant Sandstones in the Mountain south-east of Bear Valley.—An anticlinal axis, already traced, passes from the Cumberland Valley north of Strasburg at the mountain's base, into Bear Valley, traversing which it becomes the axis of the middle of the limestone belts in the W. end of Franklin County. In the synclinal trough S.E. of this axis, the Levant sandstones form that portion of the Blue Mountain which ends in Clark's Knob, near Strasburg, and in Parnell's Knob, S.E. of Loudon. Being synclinal, it has a double crest, and embraces a portion of the Surgent slate group in a small elevated valley. The N. crest is high and unbroken, bounding Bear Valley. It curves slightly towards the S., and is united at each extremity to the S.E. crest, which is much lower, in consequence of an almost perpendicular dip, and is broken by several gaps or gorges, through which the little valley is drained. It is about half a mile from the other crest at the widest part of the valley, and is scarcely perceptible as a distinct ridge when seen from the Cumberland Valley.

Clark's Knob is high and abrupt. It stands out to the W. of Strasburg, enclosed by the Matinal slate, and begins to separate into the two ridges 1½ miles from its North-eastern declivity.

Parnell's Knob is also very bold. At a point immediately N.E. of the knob, the ridge is cut by a pretty deep notch, descending in a deep ravine on the N.W. side at the mouth of Bear Valley. North-eastward of this point the mountain is high, soon dividing to form the little inclined valley of the Levant slates. The distance from the top of one knob to the other is 11 miles. The N.E. end of Bear Valley is elevated perhaps one-fourth the height of the mountain, but the other extremity is on a level with the surrounding country.

SURGENT SERIES.

GEOGRAPHICAL DISTRIBUTION.

SURGENT SLATES AND SHALES IN PERRY AND FRANKLIN COUNTIES.

Wherever the Surgent iron-sandstones or the ore sandstones in the lower part of the Surgent slate group are elevated to the surface, they form a ridge more or less marked, and in some instances several hundred feet high. Resting on the flanks of the mountain, they often form a chain of low knolls, or sometimes a continuous step or terrace. Invariably where an anticlinal axis elevates a mountain of the Levant sandstones, the Surgent iron-sandstone forms a ridge appended to its extremity; or if the rocks rise rapidly along the line of elevation, it forms a knob below the higher one of these mountains, as may be seen S. of Landisburg.

Fossiliferous Iron Ore.—Along the South-eastern base of the anticlinal Tuscarora Mountain, from Pfout's Valley into Liberty Valley, this ore has been traced, being no doubt a continuous bed. And it is curious to observe the change which takes place in its character. In Pfout's Valley it is oolitic, but has numerous well-defined fossils, giving it the usual aspect of the fossiliferous ore. Followed South-westward, the fossils disappear, and the ore is still very distinctly oolitic, and finally in Liberty Valley it graduates into a sandy ore like that of Juniata County.

The ore thus traced, as well as that of Juniata County, lies but a short distance, usually not more than 2 or 3 feet, above the white sandstone, which I have termed the Surgent ore sandstone.

In the only locality where the fossiliferous ore was found, near to the Kittatinny Mountain, it has quite a different appearance from that in the N.W. part of the county. It has all the characters of the Catawissa ore, with large encrinal rings in it. It is remarkable that this bed is below the white or ore sandstone.

Surgent Slates, Ore Shales, and Marls in Perry County—Range and Extent.—The middle and newer Surgent groups are very widely spread by the numerous axes of Sherman's Valley, and to this circumstance must be ascribed a large portion of the more fertile soil of the Western half of the county.

Pfout's Valley has very much the form of an arrow-head. It contains the Surgent slates and marls, and Pre-meridian limestone, and is bounded by ridges of Meridian sandstone and the Cadent grey sandstone. That on the S.E. is called Wildcat Ridge, that on the N.W., Turkey Ridge. It is terraced centrally by the anticlinal axis of Tuscarora Mountain, over which the formations fold on the N.E., causing the bounding ridges to unite, and to give the valley a pointed form in that direction. From Millerstown, which is situated at the end of the S.E. fork of the valley to its N.E. extremity, the distance is 8 miles, and the breadth of the S.W. end of the valley, including the ridge which separates it into two branches, is 3 miles.

The Surgent rocks extend from the Juniata River above Millerstown into Pfout's Valley for 4 or 5 miles S.E., ending in a point where the Pre-meridian limestone folds over it, in the middle of the valley. The mountain axis traverses it centrally. The dip on the S.E. side is 65°, and on the N.W. 35°. The gentleness of the North-western dip is due to the contiguity of Glover's Valley axis. The ore and iron sandstones lapping over the anticlinal axis in a broad ridge in the S.W. end of Pfout's Valley, give it the arrow shape we have mentioned by dividing it into two prongs or barbs. This ridge is broad and high, extending more than 2 miles N.E. of the Juniata, and forming an apparent continuation of Tuscarora Mountain. Both of these sandstone strata are well developed, and can be seen on the turnpike.

Fossiliferous Ore, Pfout's Valley.—An ore-bank of some value exists 2 miles N.E. of Middletown. It is situated at the E. end of the sandstone ridge near the position of the anticlinal axis. The strata there dip but a few degrees E., and the bed of ore is so near the surface as to admit of the process of stripping. The ore is several feet above the upper layer of white sandstone. It is from 8 to 10 inches thick. It differs in appearance from the ordinary fossiliferous ore of the region, being more compact, and having an oolitic structure. It seems not to make a very good iron. None was observed on the N.W. side of the ridge in Pfout's Valley, and probably it assumes a sandy character in that direction. The ore was traced from Brant's Ore Bank to the Juniata above Millerstown. Its position for mining is, however, much less favourable as it assumes a steeper inclination. It has been mined half a mile above Millerstown.

The South-eastern limit of the Levant series ranges a quarter of a mile from Wildcat Ridge, passing through Millerstown.

Surgent Rocks in Racoon Valley.—Racoon Valley extends from the Juniata 10 miles South-westward along the S.E. base of the anticlinal Tuscarora Mountain. It is bounded on the S.E. by a high ridge called Racoon Ridge, consisting of the hard grey Cadent sandstone. The valley is narrow, and composed entirely of South-east-dipping strata, and is of the same breadth throughout. It is much covered by transported soil and rocks. The Surgent strata here dip 40° S.E., composing the North-western half of Racoon Valley, and resting high on the flank of the mountain.

The ore sandstones form a ridge on the N.W. side of the valley, resting somewhat on the flank of this mountain. This ridge on the Juniata is separated from the mountain by a deep ravine, which, to the S.W., becomes nearly obliterated. The ridge is cut by numerous gorges, through which the rivulets that form Racoon Creek flow. It extends 8 or 9 miles from the river, when it becomes confounded with the mountain slope in connection with a steeper dip in the strata. The fossiliferous ore ranges along this ridge continuously, occupying the S.E. flank. It is reddish brown, compact and oolitic, and has few or no fossils. Towards the river it has been opened, and has the same aspect as at Brant's Mine. Its thickness is not considerable.

Surgent Rocks South-west of Racoon Valley, and in the neighbourhood of Ickesburg.—The first anticlinal axis, or that of North Horse Valley, originates in the Surgent shales in the South-western end of Racoon Valley. By this the belt is widened, and its South-eastern edge made slightly to diverge from the mountain, passing from the middle of Racoon Valley to Ickesburg, which is close to the Scalent limestone. The tract of Surgent slates and marls N.W. of Ickesburg is about a mile and a quarter wide, with three dips, the S.W. limit being half-way up the height of the mountain. The ore sandstone, the ore, and the iron sandstone crop out high on the slope, and do not produce any inequality of surface. They dip 50° S.E. The second anticlinal axis brings the Surgent slates to the surface three quarters of a mile N.E. of Ickesburg, in a narrow zone which passes under the S.E. side of the town, half a mile S.W. of which it coalesces with the main body of the formation, N. of it, by the ending of the synclinal axis of the Scalent limestone on which the town is built. The third anticlinal axis also passes from the limestone into the Surgent marls in the same neighbourhood.

There is thus a wide tract of Surgent marls and slates extending from near Ickesburg for 5 or more miles South-westward, traversed by the first and second anticlinal axes, with the third axis dying away in it. Between Ickesburg and Linn's Mill (nearly 3 miles asunder), the surface has the usual rolling outline of the marls, and the sandstone belts crop out on the mountain without producing any inequality.

At Linn's Mill the second anticlinal axis elevates the Surgent iron sandstone, producing a high ridge, which is the N.E. prolongation of Conecocheague Mountain. The Levant white sandstone is not brought up for more than 2 miles further South-westward. The N.E. extremity of Conecocheague Mountain, composed of the iron sandstone, has a more ragged outline than further to the S.W. The fossiliferous iron-ore was observed at several points on its S.E. flank. It was detected on the road a few hundred yards S.E. of Linn's Mill, with a S.E. dip. It is oolitic in its structure, and rests on the white sandstone. It is only a few inches thick.

Surgent Slates and Marls.—The formation on the N.W. side of the Conecocheague Mountain, stretching South-westward into Juniata County, forms Liberty Valley.

Liberty Valley is bounded on the N.W. by the South-western extremity of the anticlinal Tuscarora Mountain, and on the S.E. by the Conecocheague Mountain and the Mountain Axis. The N.W. division of which prolonged is the monoclinal Tuscarora Mountain. The valley opens out into Sherman's Valley at Linn's Mill, and into Tuscarora Valley two miles E. of Waterford. Its greatest width is not more than a mile, and its South-western extremity is narrower. It is a poor valley, and, as might be anticipated, is much covered with mountain debris and rocks.

The Surgent marls and slates, traversed by the first anticlinal axis, occupy Liberty Valley for 5 miles or more from its North-eastern extremity.

West of Linn's Mill, the Levant ore sandstone, cropping out along the Tuscarora Mountain, begins to produce a distinct but broken ridge, which thence South-westward occupies the same situation for the whole length of the valley. Fossiliferous ore, but of a poor quality, was observed upon it. The rocks dip 40° S.E.

The first anticlinal axis elevates the ore sandstone into a short ridge, which, to the S.W., disappears by denudation. This is near the centre of the valley; it is broken and of little importance. No iron ore was seen on it.

The iron sandstone, which forms the N.E. end of Conecocheague Mountain, where the Levant white sandstone emerges, 2½ miles from Linn's Mill, lies along the flank of the mountain, but does not influence the topography or outline of the surface.

Between each of these belts of sandstone there is, of course, a synclinal axis of the shales and marls.

Where the first anticlinal axis elevates the Levant white sandstone into the knob standing out into Liberty Valley at the place called the Locking of the Mountains, the next higher strata are separated into two synclinal belts, the South-eastern of which enters into the deep hollow between the knob and the Conecocheague Mountain, ending in a point.

The other composes the S.W. portion of Liberty Valley, uniting with the same formations which range on the N.W. side of the anticlinal Tuscarora Mountain, by saddling the axis 2½ miles N.E. of Waterford. The strata which are associated with the fossiliferous ore are, in Liberty Valley, thrown, as we have seen, into several lines of outcrop, but the ore is either absent or of a very poor quality. In the N.E. end of the valley, specimens were obtained which seem to show the passage of the bed of oolitic ore into a ferruginous sandstone as it advances S.W. In the W. end of the valley it was not detected in its usual position, but may have been discovered since the date of our explorations.

Surgent and Scalent Rocks South-east of Conecocheague Mountain.—The Surgent slates and marls S.E. of Conecocheague Mountain, extend from Buffalo Creek below Linn's Mill, to a point opposite Germantown, a distance of 12 miles, with an uniform S.E. dip except where the fourth anticlinal axis passes into it, soon to die away opposite Conecocheague Gap. This gives the Scalent limestone a sweep to the N.E., round a synclinal point of the Meridian sandstone. The Surgent older slate lies high on the mountain. The ore and iron sandstones form a few hills on the flank in the neighbourhood of the gap, but do not affect the surface further to the W.

Fossiliferous Ore occurs along the S.E. flank of Conecocheague Mountain. It is of the oolitic variety, with few or no fossils. The strata thus traced dip 50°—60° S.E. The ore lies therefore near the mountain.

West of Germantown this belt of Surgent slates becomes a broader tract, which occupies exclusively the S.W. end of Sherman's Valley. We may trace these rocks with the same dip along the flank of the Conecocheague Mountain until they enter the deep hollow between Round Top and that mountain, and end 7 miles S.W. of Germantown.

Surgent Rocks on the Fifth Anticlinal Axis.—There is a slender belt of the Surgent red shales and marls originating between 3 and 4 miles N.E. of Germantown, and passing a few hundred yards N.W. of that place. It is bounded on both sides by a narrow synclinal belt of limestone, and traversed by the fifth anticlinal axis. It coalesces with the wide district of Surgent slates and marls in the S.W. end of Sherman's Valley, by the ending of the two narrow belts of Scalent limestone bounding it, three-fourths of a mile S.W. of Germantown. From thence we trace the anticlinal line, still in the red shale and slates, to a point near the end of Round Top Knob, where the Surgent iron sandstone is brought up. The sandstone, with a S.W. dip, forms a hill S.W. of the Tannery, extending into the hollow between Round Top and Conecocheague about one-half of a mile. The rising of the Levant white sandstone along the axis in Round Top, divides and turns aside the Surgent slates with opposite dips. The N.W. belt forms, with strata nearer to the Conecocheague Mountain, a tongue reaching perhaps 2½ miles further; the other belt S.E. of Round Top enters the little valley between it and the Rising Mountain.

I may here mention that an anticlinal axis confined to the Surgent slates and marls exists between the fifth anticlinal axis and the Conecocheague Mountain. It originates 1½ miles W. of Germantown, and passes to the mouth of the hollow between Round Top and Conecocheague. It is 3 or more miles in length, and develops the ore sandstone in the ridge immediately N. of the Tannery. The ridge is low and clings to the base of the mountain, and its rocks dip 50° S.E. and 40° N.W. West of the Tannery it contains the oolitic variety of the fossiliferous iron-ore, but apparently in small quantities and of little value.

Surgent Rocks on the Sixth Anticlinal Axis.—The sixth anticlinal axis elevates the Surgent red shale in a belt very similar to that of the fifth, and but a few hundred yards S.E. of it. It commences at the Stone Church four miles N.E. of Germantown, passing immediately to the S.E. of that place. The main valley road follows it from the church to the town. Its greatest width is one-fourth of a mile. In the neighbourhood of Germantown it is merged into the broad district of the same formations.

Tracing the axis to the S.W. it continues in the red shale for some distance and lifts the Surgent slates, passing into the hollow between the Round Top and Rising Mountain.

Surgent Rocks on the Seventh Anticlinal Axis.—The seventh anticlinal axis, where it elevates the Scalent limestone and Surgent marls, 1½ miles N.E. of Andersontown, has gentle dips on both sides, and influences a wide belt of rocks. The N.W. band of the marls, diverging rapidly from the axis of elevation, passes half a mile N.W. of Andersontown, and thence in a straight line to a point a few hundred yards S. of Germantown, where it unites with the belt of the sixth anticlinal axis.

The synclinal tongue of Scalent limestone between the seventh and eighth axis is short, terminating a little distance S.W. of Cedar Run on the main road. The seventh anticlinal axis throws up the Surgent ore sandstone at Enslow's Mill, a mile and a half S.W. of Andersontown. Further S.W., this and the iron sandstone, which also appears, form the anticlinal ridge to the S.E. of Germantown called Buck Ridge.

Buck Ridge rises very gradually, becoming higher and broader until it reaches the end of the Rising Mountain. It is 4 or 5 miles in length, and perhaps 200 feet in altitude at the highest point. The ore sandstone lies near the base, on each side of the iron sandstone which forms the crest.

Fossiliferous Ore of Buck Ridge.—A sandy variety of this iron ore outcrops E. of Germantown on the

S.W. flank of the ridge. It lies above the ore sandstone, and is probably of little value. The Surgent red shale extends along the base of the ridge.

Where the Levant white sandstone appears in the Rising Mountain, the Surgent slates separated on the N.W. enter between it and the Round Top, running several miles further. The hollow or little valley between the Rising Mountain and Round Top is uncultivated and barren. The Surgent slate group, traversed by the sixth axis, occupies it exclusively, reaching but a little way up the slopes of the mountain. The iron sandstone forms several hills at its mouth S.E. of the Tannery.

Surgent Rocks on the Eighth Anticlinal Axis.—The Surgent marls are lifted by the eighth axis N. of Loystown at the base of the *Limestone Ridge*, the topography and structure of which will be described in connection with the Pre-meridian and Meridian rocks. The belt belonging to the eighth axis unites with that of the ninth a mile S.W. of its origin, by the ending of the synclinal point of the Scalent limestone. The N.W. limit of the Surgent marls is near the base of the limestone ridge, which includes both the Scalent and Pre-meridian limestones. This margin is a straight line for 5 or 6 miles S.W., when it meets the same formation dipping S.E. from the seventh axis S.W. of Cedar Run.

Following the axis, it exposes the marls for 6 miles, when the ore sandstone, and afterwards the iron sandstone, are developed, and form a ridge. This is the second ridge S.E. of Germantown. It has no name although high and distinct. From its origin to its S.W. extremity the distance is nearly 8 miles. At its commencement it is low and narrow, gradually expanding, until at its S.W. end it is at least 300 feet high, and a mile in breadth through the base. Being formed by the same anticlinal axis as that of Amberson's Knob, it is in a line with it. Several notches indent it, and it is cut by Sherman's Creek below Holabaugh's Mill. The rocks composing it dip 40° S.E. and 80° N.W.

Fossiliferous Iron Ore.—Some poor specimens of the oolitic variety of the fossiliferous iron-ore were discovered by us, but there are no indications of a sufficiency for economical uses, nor does it seem to be of good quality. Of course, there is a double line of outcrop along this anticlinal as well as along the Buck Ridge.

The red shales occupy the valley between the two ridges lying in a regular synclinal trough. They are traversed by Brown's Run.

As Amberson's Knob consists of the Levant white sandstone, the Surgent slates separate to each side of it. On the N.W. a regular synclinal belt of these slates extends 3½ miles S.W., in a deep hollow or valley between the knob and the Rising Mountain.

Surgent Rocks on the Ninth Anticlinal Axis.—The Surgent Marls are exposed by the ninth axis between a spur of the limestone ridge and the main ridge, 2 miles W. of Bloomfield, with the zone S.E. of it, that of the tenth axis half a mile from its origin. Its N.W. limit extends along the base of the limestone ridge for 6 or 7 miles, until it coalesces with the belt of the eighth axis. The ninth axis is saddled by the red shale for 7½ miles, these composing part of the western end of the Bloomfield Valley. At Waggoner's Mill it reveals the Surgent ore sandstone, and further S.W. the iron sandstone, which together form a ridge extending 10 miles S.W., nearly to the base of Bower's Mountain. The average height of this ridge is perhaps 150 feet. It is broken by notches, and Sherman's Creek passes through it three times, flowing between it and the mountain for 2 miles opposite Andersontown. Opposite Germantown the ridge dies away to the S.W. on the flank of Bower's Mountain. Its rocks dip 60° N.W., and 45° S.E. The fossiliferous ore was not observed anywhere on this ridge, although close search was made for it. The Surgent slates and marls lie on each side in synclinal arrangement.

Surgent Rocks on the Tenth Anticlinal Axis.—Bloomfield, the county seat of Perry, is situated in a slender valley of the Surgent and Pre-meridian strata, bounded on the S.E. by the Mahanoy ridge composed of the Cadent grey sandstone, and on the N.W. by the limestone ridge. The greatest width of this valley is three-quarters of a mile. It is closed to the N.E., but open to the S.W. Its length is between 12 and 13 miles.

The tenth axis is the main axis of this valley. It develops the Surgent marls 3 miles N.E. of Bloomfield, and the Scalent limestone about 4 miles further N.E. That town is situated on the red shale, which there forms a belt a quarter of a mile in width, in the centre of the valley dipping 45° N.W. and 70° S.E. Holding the same position, it stretches 2½ miles S.W. to unite in a zone with the Surgent marls of the ninth axis. The marls now extend 6 or 7 miles to Loystown with the two anticlinal axes. Their N.W. limit is near the limestone ridge, and their S.E. not far from the base of the South bounding ridge of the Meridian sandstone, and beyond where that ends, it stretches in a line S.W., passing close by the County Poorhouse. This belt of the marls possesses an undulating and fertile surface.

Surgent Rocks on the Eleventh Anticlinal Axis.—The eleventh anticlinal axis brings up the Scalent limestone and Surgent marls at the S.W. extremity of the ridge bounding Bloomfield Valley on the S.E., quarter of a mile S.E. of the main road. The marl or red-shale belt extending thence S.W., is separated from the same formation N.W. of it, by a narrow synclinal axis of the limestone which ends S.W. of Loystown. On the S.E. it unites round a short point of limestone with another belt, that of the twelfth axis, one-third of a mile from its point of emergence from beneath the overlying formation. This axis, traced S.W., dies away in red shale toward the base of Bower's Mountain.

Surgent Rocks on the Twelfth Anticlinal Axis.—The eleventh, twelfth, and thirteenth anticlinal axes pass from the Pre-meridian into the Surgent rocks in a line which is nearly 2 miles N.E. of the Landisburg and Ickesburg road, the red shale on each of them beginning 1 mile N.E. of the road. The limestone between the eleventh and twelfth does not reach the road; but another tongue between the twelfth and thirteenth crosses it.

The twelfth anticlinal axis dies away with the eleventh in the Surgent red shale between Bower's Mountain and Loystown.

Surgent Rocks on the Thirteenth Anticlinal Axis, or that of Bower's Mountain.—This axis from the point near where it passes into the Surgent marls, to the end of Bower's Mountain, lies chiefly in the red shale, influencing a wide belt. Its S.E. limit is near the N.W. base of Bell's Hill. It assists in forming a wide area of red-shale land S.E of Loystown.

The thirteenth axis, elevating the Surgent ore and iron sandstones, forms the S.E. extremity of Bower's Mountain for 2½ miles. This portion of the mountain has a ragged outline. The effect of denuding currents, sweeping round the end of the mountain to the S.E., has been to cut down much of the North-west-dipping strata, so that the line of elevation passes a considerable distance N.W. of the actual point of the mountain.

Following the North-west-dipping Surgent slates and marls, as they are separated from those S.E. by the intrusion of the Levant white sandstone, they range along the N.W. flank of Bower's Mountain to its S.W. end, and entering the hollow or enclosed nook between it and Amberson's Knob, the belt there ends. It reaches half the way up the mountain slope. The sandstone produces no inequality of surface. The general dip is about 50° N.W. No fossiliferous ore was seen on Bower's Mountain.

The Surgent slates and marls, as we have traced them in connection with the axes in the foregoing sections, form a wide and varied district to the N.W. of Bower's Mountain, and occupy exclusively the S.W. end of Sherman's Valley from near Germantown, entering between the mountain-knobs which there occur, and communicating with the tract of the same formation which belts the N.W. side of the county along the Conecocheague and Tuscarora mountains. Sherman's Creek and its tributaries flow upon these rocks. The upper members or marls, and shales, form fine arable land, unless where covered by debris. The ridges of sandstone which form so conspicuous a feature are usually rocky and uncultivated on their slopes, but where the Surgent ore shales, flanked by the sandstone, form the broad crest, as they often do, a tolerably good agricultural soil prevails.

It would appear that the fossiliferous ore of the portion of the county now under consideration is of little value. Only at intervals could it be found, and it seemed to be of inferior quality. Although brought to the surface along so many lines of outcrop, the bed is undoubtedly thin. Its position here is, without exception, above the ore sandstone.

Surgent Rocks South-east of Bower's Mountain Axis.—The red shale, or more properly the Surgent and Scalent marl group, S.E. of this axis, has its S.E. limit near the base of Bell's Hill; but extending further S.W. it unites with the same shales, dipping in a contrary direction from the fourteenth anticlinal axis around a synclinal point of the Scalent limestone, perhaps one-third of a mile from the end of that hill. These shales pass into the mouth of Shaeffer's Valley. The ore and iron sandstones S.E. of Bower's Mountain axis (thirteenth) assist, as before stated, in forming the extremity of the mountain, but being separated by the intrusion of the Levant white sandstone along the anticlinal axis, this belt runs along the S.E. flank of the mountain in Shaeffer's Valley.

Surgent Rocks on the Fourteenth Anticlinal Axis.—The fourteenth axis develops a belt of the Surgent marls with their red shale between the S.W. extremity of two limestone ridges, one-third of a mile N. of Landisburg. This little belt extends towards the mouth of Shaeffer's Valley, mingling with the same formation on the N.W. a short distance from its origin. On the S.E. it is separated from the red shales in the neighbourhood of Landisburg by a slender synclinal zone of Scalent limestone, extending to Sherman's Creek. There, accordingly, it coalesces with the same formation, lying nearer to Pilot Hill. The Anticlinal axis, passing into Shaeffer's Valley, soon flattens down in the upper shales.

Surgent Rocks on the Fifteenth Anticlinal Axis.—The fifteenth axis lifts the Surgent and Scalent marls from beneath the overlying Scalent limestone; between two low ridges of the Pre-meridian series, half a mile N.E. of Junkin's Mill, the Scalent limestone emerges from the Pre-meridian limestone, at a point about 1 mile further to the N.E. The shales thus thrown to the surface have their N.W. border near the base of the ridge, extending N.E. of Landisburg. The line passes immediately N.E. of that town, extending thence almost straight to the Creek near which this belt of the marls merges into the more extensive tract to the W. The S.E. edge passes near Junkin's Mill, the formation sweeping round a short synclinal point of limestone to unite with another tract of the same strata thrown into an opposite dip by the seventeenth axis. The fifteenth axis, passing a short distance S.E. of Landisburg, flattens out in the red shale near the creek, a mile from that place. The town is situated on the North-west-dipping strata of this axis.

The Sixteenth Anticlinal Axis does not bring to the surface any belt of the Surgent rocks, but traverses only the Pre-meridian, Meridian, and Cadent series.

Surgent Rocks on the Seventeenth Anticlinal Axis.—The seventeenth and eighteenth axes pass from the N.E. into the Surgent marls, nearly opposite the same point, which is about 5 miles E. of Landisburg, and a mile or more S.E. of Perry Furnace, and close to the stream on which it is situated. They lift the Levant limestone for a short distance E. of this. The marls and red shales traversed by the two axes form a little valley bounded by ridges of the higher formations. The South-eastern of these is the Quaker Hill, composed of the Meridian sandstone, and the North-western the ridge of Cadent grey sandstone immediately S. of Perry Furnace.

The seventeenth anticlinal axis occupies the S.W. side of the valley, passing out of which it makes a curve to the W., to enter Pilot Hill. From the point where it first appears in the Surgent rocks to the end of Pilot Hill, it is in the Surgent marls and slates which are thus widely expanded. These unite with the other belt of the same strata, containing the fifteenth axis, to form the fine farming district to the S. and E. of Landisburg, extending into the mouth of Shaeffer's and Kennedy's valleys. The Surgent iron sandstone thrown up by the seventeenth axis, mantles round the Levant white sandstone composing the E. end of the Pilot Hill. By the deep erosion of the Surgent older slate, the highest point of the knob rises out of a small elevated basin encircled by the crest of the iron sandstone. The outline, therefore, has not a regular slope, but a step or offset. The white sandstone comes to the surface about $1\frac{1}{2}$ miles from the extreme North-eastern end of Pilot Hill—separating the Levant slates and marls into two divisions—that on the S.E. entering Kennedy's Valley, and the other passing South-westward in Shaeffer's Valley.

Shaeffer's Valley extends from the creek near Landisburg, 11 miles S.W., having a very uniform outline, which, at the end of that space, is disturbed by the origin of the spur from the Kittatinny Mountain in the neighbourhood of Three Square Hollow.

Shaeffer's Valley is bounded on the N.W. by the anticlinal Bower's Mountain, and on the S.E. by the Pilot Hill and its continuation, the Blue Mountain west of Dublin Hollow. For 11 miles from its mouth it is confined by even mountain-slopes which nearly meet at the stream in its centre. Beyond this, Bower's Mountain makes a curve Westward, and then resumes its original bearing. Opposite the curve the mountain axis rising more on the N.W. side of the valley, this divides into a N.W. and a S.E. Branch. The first or less direct prolongation traced S.W., communicates with or becomes North Horse Valley of Franklin County; the other, or S.E. portion, the true continuation of Shaeffer's Valley, is gradually elevated into a table-land which terminates at the Three Square Hollow, about 15 miles from the Eastern end of the valley. The table-land alluded to is crossed by a road from Three Square Hollow immediately after it ascends the flank of the Blue Mountain.

Surgent Rocks in Shaeffer's Valley.—As we have already stated, the fourteenth and fifteenth anticlinal axes pass into the mouth of Shaeffer's Valley, where they terminate, flattening out in the red shales. The valley thence S.W. to the origin of the mountain axis, is simply a basin of the Surgent rocks which extend up half of the height of Bower's Mountain with a steep S.E. dip. The sandstone produces no inequality of surface. No fossiliferous ore was detected, although careful search was made for it.

The formation on the S.E. side of the valley reaches one-third of the height of the Blue Mountain, the sandstone forming a line of buttresses along its flank. The red shale of the centre of the valley, almost the only member of the marl group here present, is cultivated. It is but a narrow strip, and often covered with the fragmentary rocks and soil of the mountain.

In the S.W. end of the valley S.E. of the mountain axis, the Surgent iron and ore sandstones form several considerable hills. As the S.E. division of the valley rises towards the table-land, the whole of the Surgent slate group crops out and terminates. We postpone to another place the description of the belt of Surgent rocks which, passing out of Shaeffer's Valley, communicates with Horse Valley.

Surgent Rocks on the Eighteenth Anticlinal Axis.—The eighteenth axis developing the Surgent rocks 5 miles E. of Landisburg, the strata which arch it very soon mingle with the same formation containing the seventeenth axis in the little valley already described. The S.E. limit of the series is near the base of Quaker Hill. About a mile W. of the Warm Spring it sweeps round a synclinal tongue of limestone, to become the N.W. margin of the next belt developed by the nineteenth anticlinal axis. The eighteenth axis, from the point where it enters the Surgent rocks, to the road half of a mile S. of Waggoner's Mill, is in the marls or red shale. Immediately S.W. of the road it elevates the ore sandstone, which forms a ridge, passing along the S.E. side of Kennedy's Valley at its mouth, and uniting with the N.W. flank of Welche's Knob. The ridge is broad and rounded, and perhaps $1\frac{1}{2}$ miles in length before it is confounded in the slope of the mountain.

Fossiliferous Iron Ore.—On this ridge, which is $1\frac{3}{4}$ miles N.W. of Oak Grove Furnace, the fossiliferous ore was discovered. Its geological position is immediately below the ore sandstone, the only locality in the county where it was found in this relation. The ore differs in aspect from that found elsewhere, corresponding more nearly to the fossiliferous ore of Bloomsburg and Catawissa. It is not calcareous, is composed of flattened flakes with small fossil shells and crinoidal rings half an inch in diameter. It is apparently pure and rich. This ore has exactly the stratigraphical position of that found in the Little Cove. In all Dr Henderson's researches, he was unable to detect it in the intervening country. The ore on the ridge here spoken of has of course a double line of outcrop. It first appears about half a mile from the main road before alluded to. The red shales fold round the ridge and occupy the valley at both sides of it.

Surgent Rocks on the Nineteenth Anticlinal Axis.—This is the axis of Welche's Knob. It passes from the Pre-meridian into the Surgent rocks a little N. of the Warm Spring. The red shales thus brought up communicate round a short synclinal tongue of limestone with those traversed by the eighteenth axis. Their S.E. limit is rather more than half a mile N.W. of Oak Grove Furnace. From the point where the nineteenth anticlinal axis passes into the red shale to the end of Welche's Knob, the distance is a mile and a half. The iron sandstone forms the end of the knob, rising high up on it. As in Pilot Hill, the Surgent older slate forms a little encircled valley or basin, in the middle of which the highest part of the knob of Levant white sandstone rises. The basin in both instances is drained through a deep notch. Where the Levant white sandstone appears in Welche's Knob, the Surgent slates, with N.W. dip, enter Kennedy's Valley. The formation on the S.E. side of the knob sweeps round W. of Oak Grove Furnace, and is continued N.E. as the belt of the Blue Mountain.

Kennedy's Valley is the valley enclosed in the spur of the Blue Mountain which is S.E. of Dublin Hollow. The Pilot Hill and Welche's Knob bound its E. end, and the prolongation of the North-west-dipping strata of the latter and the South-east-dipping rocks of the former, constituting the mountains on each side, unite in the synclinal knob closing the W. end of the valley.

Kennedy's Valley is between 7 and 8 miles in length, and is narrow, the mountain slopes meeting at the bed of the stream. It is occupied exclusively by Surgent slates and marls. It is a regular synclinal axis, the red shales lying in the middle. There is a short axis at the E. end of the valley in the red shale. It forms a hill to the W. of Waggoner's Mill, against which Sherman's Creek flows. The eighteenth anticlinal axis also dies away in the E. end at the base of Welche's Knob. The Surgent marls reach about one-half the way up the slopes of the bounding mountains.

The iron sandstone on the flank of Welche's Knob forms ragged bare hillocks or knobs which disappear towards the W. The flank of the mountain on the N.W. has a more even surface. In the W. end of the valley there are several considerable hills which result from the resistance to denudation, caused by the iron and ore sandstones. No fossiliferous ore was detected on them.

Surgent Slates and Shales in the Blue Mountain from the Susquehanna to M^cClure's Gap.—The Surgent iron sandstone has its maximum thickness in the belt which is on the N.W. flank of the Blue Mountain west of the Susquehanna. From this condition, in connection with the perpendicular attitude of the rocks, it arises that the inferior slates occupy the crest of the mountain, which is broad and rounded. The Levant white sandstone is on the S. brow, and the iron sandstone on the N. These harder strata have protected the Surgent older slate between them. The slate is cultivated at various points, giving the mountain an unusual aspect. As already mentioned, the mountain is singularly undulating in its outline. The Surgent newer slates, ore shales, and marls, are on the N.W. flank and base, forming the S.E. side of the slender valley called Polecat Valley. At the Susquehanna the marls and Cadent rocks are in contact, but in the neighbourhood of Sterret's Gap the Meridian sandstone comes between. Further west the Pre-meridian limestone appears beneath the latter. To the S.W. of Oak Grove Furnace the middle and upper Surgent groups sweep round to unite in synclinal form with the South-east-dipping strata on the flank of Welche's Knob, and here the Surgent slate group descends a little on the mountain, the iron sandstone forming eminences on the slope, and the ore slates underlying a portion of the Little Nook south-west of the furnace called Green's Valley. No fossiliferous ore was detected on the Blue Mountain.

Surgent Slates and Shales in South Horse Valley.—From the point where the *Short Mountain* axis originates in the S.W. end of Shaeffer's Valley, a long slender valley extends S.W. for about 15 miles, opening into South Horse Valley west of Roxbury. It lies between the Blue Mountain and that mountain which is the S.E. division of Bower's Mountain. It is entirely uninhabited. It is synclinal, embracing the Surgent slates communicating on the N.E. with the same formations in Shaeffer's Valley. The slates extend high on the bounding mountains, the iron sandstone at some points producing hills. The Surgent older and newer slates probably exist throughout it. At the Germantown and Shippensburg road both the valley and the table-land N.E. of it are used as wild pasturage for cattle by the farmers of Cumberland County.

Horse Valley Proper.—This is but an extension of South Horse Valley, but is wider, and admits of cultivation. The crests of the mountains bounding it are about a mile and a half apart. South Horse Valley is closed to the S.W. by the union of its bounding mountains in Jordan's Knob. It was mentioned before that the thirteenth anticlinal axis extending into Horse Valley, forms a knob of the Levant white sandstone in its S.E. end. This is about 3 miles N.E. of the Fannettsburg and Strasburg road. The axis lies towards the N.W. side of the valley. The division of the valley N.W. of the knob is only a narrow elevated ravine, which terminates on the more northern of the two knobs, called Clark's. The main Horse Valley is about 12 miles in length. It is entirely occupied by the Surgent slates and red shale. A synclinal belt of the slates originating on Clark's Knob extends several miles S.W., where it unites around the anticlinal knob with the synclinal and wider belt of the N.E. prolongation of Horse Valley. The formation then extends 4 or 5 miles S.W., with four dips, when the thirteenth axis flattens down, and the S.W. portion of Horse Valley is a general synclinal trough. The Surgent slates reach nearly to the crest of the N.W. bounding mountain, but not so high on the mountain to the S.E. The red shale occupies the centre of the valley, and the iron sandstone crops out on the mountain-flanks. The sandstone, elevated by the anticlinal axis, forms a chain of hills for several miles along the base of the N.W. mountain.

No fossiliferous ore could be discovered in South Horse Valley.

Surgent Slates in the Insulated Ridge of the Blue Mountain South-west of Strasburg.—The portion of the Blue Mountain ending to the N.E. in South Clark's Knob at Strasburg, and to the S.W. in Parnell's Knob, is synclinal, embracing in a slender elevated valley a belt chiefly of the inferior Surgent slates. The cultivated part of Parnell's Knob has a soil derived from these slates. The belt is 9 or 10 miles long, and a quarter of a mile wide, its surface mostly covered with debris.

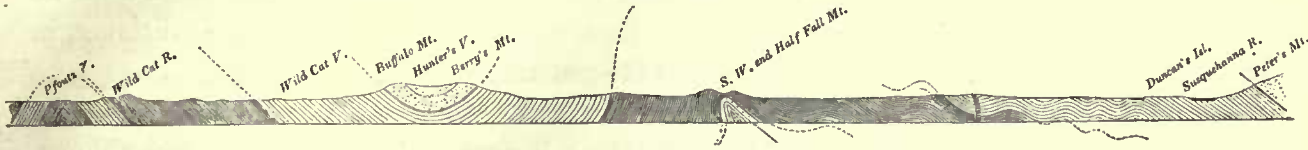


FIG. 61.—From Pfout's Valley to base of Peter's Mountain, 4 miles N.E. of Millerstown.

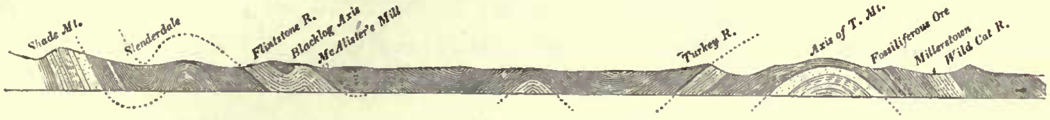


FIG. 62.—From Shade Mountain, 3½ miles N.E. of Lost Creek, to Millerstown.

FIG. 63.—From N.E. end of Tuscarora Mountain to Blue Mountain, at 4 miles E. of Sterret's Gap.

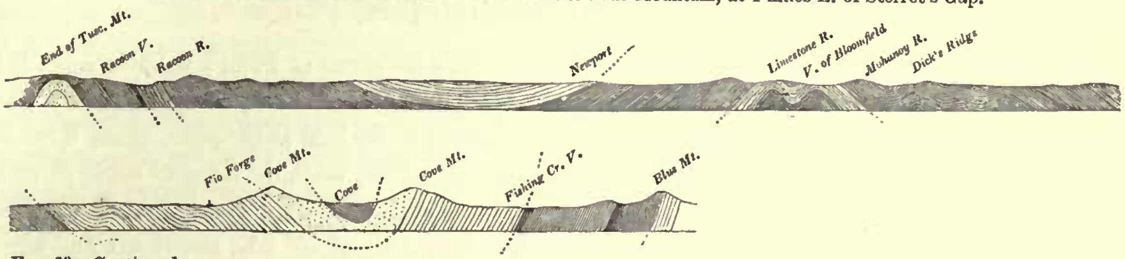


FIG. 63—*Continued.*

CHAPTER III.

SCALENT, PRE-MERIDIAN, AND MERIDIAN STRATA IN PERRY COUNTY.

SCALENT AND PRE-MERIDIAN LIMESTONES.

COMPOSITION.

THESE limestones being always in contact, and not readily distinguishable except by an attentive observer, I shall, for the sake of clearness and brevity, trace them as one great stratum.

The group—properly two formations—consists of strata of dull blue limestone, exceedingly hard and massive, enclosing a profusion of fossils. When fractured, the rock has a rough irregular surface, and is often fœtid. The fossils include a variety of genera, which will be enumerated elsewhere. Some beds of the Pre-meridian limestone consist mainly of corals of the genera *Calamapora*, *Stromapotora*, &c., showing that the rock was probably a coral reef. Beds of chert form the upper portion of the group; it is generally of a dark colour, but the long-exposed surface fragments are bleached to a light grey or ash colour, probably from the loss of combined water. Some of the uppermost beds of chert contain fossils, which, for the most part, are species characteristic of the Pre-meridian limestone. From the difference in the mechanical qualities of this and the Scalent limestone, it invariably happens that where the Pre-meridian limestone exists, it produces a low ridge, at the base of which the other lies with a level surface. When the Pre-meridian limestone is in a synclinal belt, the coralline strata and the chert form an abrupt knob, from the base of which the Scalent limestone extends often for a great distance, in the form of a long point or tongue, degraded to the general level of the country.

The maximum thickness of the two limestones occurs on the Tuscarora axis, near the Susquehanna, where it is about 340 feet. In the S.E. part of the county it is much thinner, and they are both entirely absent at the Susquehanna Water-Gap. At the Tuscarora axis, 6 miles above Liverpool, the Pre-meridian limestone measures in all 140 feet, and the chert 25 feet more. The limestone consists of a lower massive division, 60 feet thick, and an upper thinly-bedded division, 80 feet thick. Both are fossiliferous.

SCALENT AND PRE-MERIDIAN STRATA.

GEOGRAPHICAL DISTRIBUTION.

Scalent and Pre-meridian Limestone in Pfout's Valley.—The limestone of Pfout's Valley reaches between 8 and 9 miles N.E. of Millerstown, forming exclusively the N.E. portion of the valley for several miles, traversed centrally by the Tuscarora Mountain anticlinal axis. The belt ends to the N.E. at the point about 3 miles from the Susquehanna, in the direction of the axis, and widens out to the S.W., until, the Surgent marls rising in the middle of the valley, the limestone is separated into two oppositely-inclined belts. That on the N.W., along the base of Turkey Ridge, has been described already; the other, with a dip of 60° S.E., stretches along the N.W. base of Wildcat Ridge to the Juniata at Millerstown. The chert in the N.E. end of the valley forms a low hill at the base of Wildcat Ridge, but followed S.W., the limit of the formation is low on the flank of that ridge, without producing any unevenness of surface. It again forms a hill along the S.E. side of Millerstown. The limit of the limestone is a few hundred yards from the base of Wildcat Ridge.

Scalent and Pre-meridian Limestone in Racoon Valley.—The limestone belt in Racoon Valley is the continuation, on the S.W. of the Juniata, of the South-east-dipping strata of Pfout's Valley. With a dip of 40°—50° S.E., the limestones underlie the S.E. portion of Racoon Valley throughout its whole length, forming a straight zone bearing about S. 70° W. The upper stratum, or Pre-meridian limestone, produces a hill in the mouth of the valley opposite Millerstown for a mile or two, but thence S.W. the formation is entirely levelled, and generally covered by transported materials. The N.W. limit of the two limestones is in the centre of the valley, and the S.E. one near the base of Racoon Ridge. They form a belt 200 or 300 yards wide.

The belt passing from the S.W. end of Racoon Valley towards Ickesburg, presents the same S.E. dip, the upper strata forming a low ridge or hill in the line of *Racoon Ridge*, which makes an offset to the S. in connection with the passage of the second and third Anticlinal axes into the Meridian sandstone.

The *Second Anticlinal Axis* passes from the Pre-meridian limestone at a point 2 miles N.E. of Ickesburg, into the Surgent marls a mile N.E. of the same place. In consequence of this, a pointed belt of the limestone extends to the N.E., between the Meridian sandstone, which forks to the S.W., separating along the anticlinal line into two divisions. That on the N.W. is united around a tongue of the Meridian sandstone and Cadent grey sandstone, with the oppositely-dipping zone of its own formation, which passes from Racoon Valley. The synclinal axis of limestone thus formed extends along the N.W. side of the town of Ickesburg, half a mile W. of which place it ends in an acute point. The upper and harder Pre-meridian limestone of this synclinal belt composes the abrupt knob which terminates half a mile N.E. of Ickesburg, the lower or softer scalent limestone forming the belt thence S.W.

Scalent and Pre-meridian Limestones on the Third Anticlinal Axis.—The third axis passes from the Meridian sandstone rocks into the Pre-meridian limestone, 2½ miles east of Ickesburg, forming a narrow belt, which becomes wider towards the S.W., and communicates with the limestone of the second anticlinal axis, 1½ miles east of Ickesburg. The upper strata between the two axes forms a short ridge of synclinal structure, which ends in an abrupt knob about a mile E. of the town. The third anticlinal axis passes into the Surgent marls S. of Ickesburg; and at the same point, the limestones, by being thrown up by the second and third axes, cover an area in the neighbourhood of Ickesburg of considerable extent, affording room for a number of good farms which lie chiefly S.E. of that place.

Scalent and Pre-meridian Limestones south-east of the Third Anticlinal Axis.—The South-east-dipping belt of the third axis extends from a point S.E. of Ickesburg, for 3 miles S.W. to Buffalo Creek, three-quarters of a mile below Linn's Mill. The Pre-meridian limestone produces, with the Meridian sandstone, a low ridge near the N.W. base of the higher ridge of Cadent grey sandstone. The Scalent limestone borders the fertile district of the Surgent marls, which extends S.W. of Ickesburg. Tracing the limestones S.W. of Buffalo Creek, the belt continues for about a mile with a S.E. dip, when it unites with that of the same formation developed by the fourth anticlinal axis.

Scalent and Pre-meridian Limestones on the Fourth Anticlinal Axis.—A short distance S.W. of Buffalo Creek, three-quarters of a mile below Linn's Mill, the limestones emerge from the overlying formations, and extend nearly a mile S.W. in the anticlinal form, bordered on each side by the Meridian sandstone. There the outcrop joins the South-east-dipping belt just described round a synclinal tongue of the sandstones, then stretches one mile or more further S.W. with three dips, when the Surgent marls are developed by the fourth anticlinal axis. This causes a short synclinal belt on the N.W. to the S.E. of, and opposite, the Conecocheague Gap. The several belts of limestone thus traced, with the embraced synclinal tracts of the Meridian sandstone, are in a low broad ridge, which is flanked on the S.E. by the Meridian sandstone. The Buffalo Creek flows around its N.E. extremity, from which it reaches about 2 miles, when it is rendered narrower by an offset, which marks the point where the upper or Pre-meridian limestone ceases to lie in the synclinal axis. From the separation of the synclinal axis the limestones extend several miles, with a S.E. dip passing a few hundred yards N.W. of Bixler's Mill, and then forming the N.W. side of the ridge N.W. of Andersontown.

Scalent and Pre-meridian Limestones on the Fifth Anticlinal Axis.—There is a low broad ridge between Andersontown and the Conecocheague Mountain. It is about 4 miles in length, ending near the Stone Church, 4 miles N.E. of Germantown. It has a flat summit, and is half a mile through the base. This ridge is a double synclinal axis of the Pre-meridian and Meridian rocks. It is traversed centrally by the fifth anticlinal axis, forming a slender belt of the Pre-meridian limestone on either brow. The sandstone on the N.W. ends in a point near the extremity of the ridge, and some distance S.W. of this the fifth axis brings up the Surgent marls. Thus, a narrow synclinal axis of the lower or Scalent limestone is insulated on the N.W. This extends for 4 miles with a level surface near the base of the Conecocheague Mountain, and it passes one-third of a mile N.W. of Germantown, a mile W. of which it terminates in a point.

Scalent and Pre-meridian Limestones on the Sixth Anticlinal Axis.—The sixth axis brings up the limestones between the overlying rocks at a point one mile E. of Bixler's Mill, composing a belt which passes S.E. of it. This belt merges in a broad district of limestone spread out by the flattening of the seventh axis S.W. of Andersontown. The sixth axis extends along the base of the ridge in the limestones N.W. of Andersontown, until it reaches a point S.W. of the Stone Church, where it lifts the Surgent marls or shales, and a slender synclinal belt of the Scalent limestone is isolated N.W. of it. This synclinal tract of limestone extends 4½ miles South-westward, ending a mile S.W. of Germantown, which is situated on it. It is only a few hundred yards wide, and has a smooth and level surface, its limits being represented by low ridges of thin limestone near the top of the marls.

Scalent and Pre-meridian Limestones on the Seventh Anticlinal Axis.—The seventh axis, at its N.E. extremity, has a gentle dip, and influences a wide belt of rocks. The limestone saddles it a mile and a half N.E. of Andersontown, and is spread out in nearly horizontal stratification, forming a limestone district a mile and a half wide. The upper hard Pre-meridian limestone forms the escarpment of that ridge, which extends in a crescent form across the valley 2 miles N.E. of Andersontown. The Scalent limestone degraded to a level surface extends half a mile from the base of the ridge.

The North-west-dipping strata, traced S.W., pass one-half of a mile N.W. of Andersontown, uniting with the South-east-dipping strata of the sixth axis to form a basin which is S.E. of the ridge of Meridian sandstone which has been described. The upper or Pre-meridian limestone lies in this basin to the W. of Andersontown for a mile or two, producing a low ridge separated from the higher one N.W. of it by a narrow ravine which is traversed by the sixth axis.

Where the sixth anticlinal axis develops the Surgent and Scalent marls N.E. of the Stone Church, the limestone is separated to the S.W. in the basin, extending 4 miles S.W., as a narrow zone ending a quarter of a mile S.E. of Germantown. There are, then, three synclinal tongues of limestone terminating in the neighbourhood of that town, this being the most S.W. point in Perry County at which this formation occurs.

The Pre-meridian limestone, as it saddles over the seventh axis, E. of Andersontown, is met by the North-west-dipping belt of the limestone ridge, and a short synclinal point is prolonged S.W. of Cedar Run.

Scalent and Pre-meridian Limestones on the Eighth, Ninth, and Tenth Anticlinal Axes—The Limestone Ridge.—The limestone ridge bounds the division of Sherman's Valley, in which Bloomfield is situated, on the N.W. It is 19 miles long. It is broad, and low, and rather broken. Its geological structure being somewhat intricate, we shall describe this in connection with its topography.

Throughout the whole length of the limestone ridge there exists on the N.W. of it a higher, more broken, and rugged ridge, usually separated from it by an elevated valley. This ridge is composed of the Cadent rocks with a N.W. dip. It receives no distinct name, and is generally considered as a part of the limestone ridge, forming with it the entire group of ridges separating the valley about Bloomfield from that of the Little Buffalo Creek. We shall treat these as distinct, restricting the name Limestone Ridge to the S.E. one, and describing the other in connection with the Cadent rocks.

The tenth anticlinal axis lifts the limestones to the surface at the Juniata River, from which the belt extends 2 miles S.W., as a narrow zone occupying the crest of a ridge. At the end of that distance it occupies the extremity of the Valley of Bloomfield, its North-west-dipping strata forming the S.E. flank of the limestone ridge.

The N.E. end of the limestone ridge is about 6 miles from Bloomfield, from which to Juniata Furnace, which is situated between it and the ridge of Cadent sandstone, the limestone ridge is uniform. It is low, broad, and unbroken, and is separated from the ridge of Cadent sandstone by a shallow valley. The geological structure is simple. The ninth anticlinal axis originates near the N.E. end of the ridge, and develops a slender belt of limestone, which occupies the centre of the ridge, and is bordered on each side by the Meridian sandstone. A synclinal axis of this sandstone forms the S.E. brow, and a zone of limestone dipping N.W. from the tenth axis forms the S.E. flank and base. The limestone is so much covered by the debris as not to sustain a soil fit for cultivation.

To the S.W. of Juniata Furnace the limestone ridge becomes more broken and its structure more complex. From the Juniata Furnace to a point 2 miles W. of Bloomfield, it is traversed by two anticlinal axes, both of which are in the Pre-meridian limestone. The more N.W. of these, which is the eighth, originates near the Furnace, and lies in the N.W. side of the ridge; the other traverses the central part of the ridge, which it leaves 2 miles S.W. of Bloomfield, passing out into the Surgent marls between a spur and the main ridge. The portion of the ridge thus constituted is three-quarters of a mile wide, furrowed by several ravines, and separated from the ridge of Cadent grey sandstone by a continuous hollow. North-west-dipping strata form its S.E. flank and base; a slender tongue of the Pre-meridian sandstone is on its S.E. brow; and limestone, traversed by the ninth anticlinal axis, is in the centre separated from a synclinal zone of the eighth anticlinal axis on the N.W. side by a narrow trough of the Meridian sandstone.

West of Bloomfield the sandstone in both synclinal axes separating the limestone belt ceases, and the strata become degraded over the S.E. anticlinal axis, parting to the S.E. the spur alluded to, which is formed of the Pre-meridian limestone on the S.E. anticlinal axis. Between the spur of the main ridge the ninth anticlinal axis elevates the Surgent marls, and a short basin of limestone is isolated on the S.E., extending S.W. one-third of a mile or more.

It may be mentioned that the limestone ridge is cut through in an oblique direction by a broad ravine behind the synclinal spur.

From the point whence the ninth anticlinal axis leaves the ridge it is contracted in breadth and extends S.W. with more uniform features and simple structure. The eighth anticlinal axis traverses its centre for 6 miles, throwing the limestone into three dips. The upper beds in the synclinal axis are on the S.E. brow, and the N.W. side of the ridge is flanked by the Pre-meridian sandstone dipping N.W.

The portion of the limestone ridge thus constituted is half a mile broad at its base, and separated from the ridge of Cadent sandstone by a slender valley. Its crest is flat, and its S.E. side slightly furrowed. The S.E. limit of the limestone is close along its base. There is much loose chert on the surface rendering it sterile.

North of Loystown, and 8 miles S.W. of Bloomfield, the eighth anticlinal axis leaves the limestone ridge at a point marked by a short spur, and as the Surgent marls are brought to the surface, the lower beds of limestone extend a mile or more in the synclinal axis to the S.E.

From the point where the eighth anticlinal axis leaves it, the limestone ridge extends between 4 and 5 miles S.W. with a monoclinal structure. It is lower and broken by several gaps. The upper strata, flanked by the Meridian sandstone, are in the crest, while inferior beds lie along its S.E. base. It terminates by uniting with the crescent-shaped ridge of the same formations folded over the seventh axis E. of Andersontown.

Scalent and Pre-meridian Limestones, South-east of Bloomfield.—The tenth anticlinal axis elevates the Surgent formation 2½ miles N.E. of Bloomfield, separating the limestone into two zones. That on the S.E. passes a few hundred yards S.E. of Bloomfield. It has a steep S.E. dip extending close under the N. base of the Mahanoy Ridge. For 4½ miles S.W. of Bloomfield it possesses a level surface, but beyond that point it occupies the N.W. flank and base of the ridge S.E. of Elliotsburg.

This zone unites with that of the same formation, which is lifted into a N.W. dip by the N. anticlinal axis, the two forming a synclinal trough. The Pre-meridian limestone terminates in a knob three-quarters of a mile S.W. of Elliotsburg, but the Scalent limestone is prolonged in a slender tongue, which extends 2½ miles further, passing the County Poorhouse, a short distance S.W. of which it ends in a point.

Scalent and Pre-meridian Limestones on the Eleventh Anticlinal Axis.—The limestones saddle this axis at a point three-quarters of a mile S. of Elliotsburg. The North-west-dipping strata run on to form the synclinal axis which has been described. The South-east-dipping strata unite with strata inclined in an opposite direction from the twelfth axis. The basin thus formed, embracing the higher or Pre-meridian limestone, produces a low knob. The scalent limestone ends to the S.W. in a short point.

Scalent and Pre-meridian Limestones on the Twelfth and Thirteenth Anticlinal Axes.—The limestones arch over the twelfth and thirteenth anticlinal axes, which end opposite the same point, which is about half a mile N.E. of the Landisburg and Ickesburg road, 2 miles N. of the former place. Between the two axes the lower beds of the Scalent limestone extend as a synclinal tongue crossing the road. The Pre-meridian limestone forms the S.W. portion of a broad hill, in which two ravines, separated by a synclinal projection, mark the position of the two anticlinal axes.

The limestones, separated S.E. of the thirteenth anticlinal axis, stretch along the N.W. base and flank of Bell's Hill, around the end of which the belt unites with another of the same formation lifted into a N.W. dip by the fourteenth anticlinal axis. A trough of limestone is thus formed which extends three-quarters of a mile or more South-westward, ending near Sherman's Creek, below the point of Bower's Mountain. Bell's Hill, in the same synclinal axis, embraces the Pre-meridian limestone and Meridian sandstone, and the Cadent grey sandstone. It is three-quarters of a mile N. of Landisburg.

Scalent and Pre-meridian Limestones on the Fourteenth Anticlinal Axis.—The Pre-meridian limestone appears at Perry Furnace, where it is brought up by the fourteenth axis. From that point we trace it S.W for 4 miles in a slender belt, chiefly covered by the debris of the Meridian sandstone bordering it. It passes N. of McAffee's Fulling Mill, and thence to the S.W. it occupies the hollow between the two ridges N.W. of Landisburg. At the N.E. extremity of this hollow, the fourteenth axis discloses the Surgent marls, and the Scalent limestone is subdivided. The N.W. branch unites round Bell's Hill with strata which dip S.E., form in a synclinal axis already noticed. On the S.E. another synclinal axis occurs, extending from the end of the ridge at Landisburg to Sherman's Creek, in the mouth of Shaeffer's Valley, where it ends in a point.

Scalent and Pre-meridian Limestones on the Fifteenth Anticlinal Axis.—The fifteenth axis elevates the limestones a mile S.W. of Perry Furnace into a narrow zone, which, with the preceding axis, cause a low barren intervening synclinal ridge of the Meridian limestone and Cadent grey sandstone lying between Perry Furnace and M^cAffee's Fulling Mill.

The *fifteenth axis* develops the Surgent marls or red shales, a mile and a quarter N.E. of Landisburg, from which point a monoclinal belt of limestone, with a N.W. dip, stretches to Landisburg on the flank and base of a low ridge, which ends at that town. It there meets the South-east-dipping belt of the fourteenth axis, and extends in a synclinal tongue a mile further to the S.W. as described.

The limestone separated on the S.E. of the fifteenth axis soon terminates at Jenkin's Mill, in a synclinal axis formed by the union of the belt with that to the S.E. of it.

Scalent and Pre-meridian Limestones on the Sixteenth Anticlinal Axis.—This is a slender isolated zone of limestone, traversed centrally by the axis. It extends from the end of Dick's Ridge 4 miles S.W., vanishing a mile and a half S.E. of Perry Furnace. It is 200 or 300 yards wide, bounded on each side by the Meridian sandstone. It occupies, together with the adjoining sandstone, the N.W. side of the low barren ridge which stretches immediately S.W. of the end of Dick's Ridge.

Scalent and Pre-meridian Limestones on the Seventeenth and Eighteenth Anticlinal Axes.—The limestones are brought to the surface by the seventeenth axis, immediately S.W. of the end of Dick's Ridge, where some quarries supply the country to the S.E. with limestone. Thence S.W. for 3 or 4 miles they form a belt about one-third of a mile wide, occupying the central part of the low ridge before alluded to.

The eighteenth axis develops the limestone three-fourths of a mile from the end of Dick's Ridge, forming a zone between 100 and 200 yards wide, which, in the course of a mile and a half, is united near Saddler's Lime-kilns with the belt to the N.W. From that point S.W. to the Perry Furnace Run, or near it, a distance of a mile and a quarter, the limestone is traversed by the two anticlinal axes, half a mile asunder .The axes (seventeenth and eighteenth) pass into the Surgent marls, nearly opposite to the same point, and the limestone is not prolonged in the synclinal axis between them, so that it is divided into two belts, which border the division of Sherman's Valley north of the Quaker Hill. The more N.W. of these belts extends along the S.E. base of the high ridge, which is S. of Perry Furnace. It has a N.W. dip, and its surface is level, and much covered with debris of the Meridian sandstone. It terminates by uniting with the South-east-dipping strata of the fifteenth axis, near Jenkin's Mill, a mile E. of Landisburg. The S.E. belt forms the N.W. flank and base of the broken ridge which lies N.W. of Gibson's Mill and the Warm Spring, and is termed the Quaker Hills. Its strata dip 40° S.E. They meet the same formation lifted into an opposite dip by the nineteenth axis, in the S.W. end of the Quaker Hills, and terminate in a synclinal point, three-fourths of a mile W. of the Warm Spring.

Scalent and Pre-meridian Limestones on the Nineteenth Anticlinal Axis.—The division of the Quaker Hills which is directly N.W. of the Warm Spring is broad and rather high. The nineteenth axis elevates the Pre-meridian limestone between the overlying Meridian sandstone, a mile N.E. of the Warm Spring, forming a zone which occupies the S.E. slope of the Quaker Hills, separated from the limestone on the other flank by a synclinal axis of the Meridian and Cadent sandstones. These zones of limestone meet to the W. of the Warm Spring, and the anticlinal axis, passes into the Surgent marls, separating a short synclinal tongue on the N.W. from a South-east-dipping belt, which extends for 3 miles S.W., where it ends by meeting the belt, which is found at the base of the Blue Mountain. This takes place a half or three-fourths of a mile W. of the Oak Grove Furnace.

Scalent and Pre-meridian Limestones at the North-west Base of the Blue Mountain.—Both of the limestones are entirely absent at the Susquehanna Water-Gap, and no traces of them appear E. of Sterret's Gap. Limestone makes its appearance between Sterret's Gap and the Oak Grove Furnace, where it is quite thin. Nearer to the Furnace it becomes thicker. It has a steep N.W. dip, and there is a short axis or contortion in the strata on which the Furnace is situated. Traced S.W. from the Furnace, it unites around the base of the hill on which the ore-banks are situated, with the belt before described.

MERIDIAN STRATA IN PERRY COUNTY.

GEOGRAPHICAL DISTRIBUTION.

Meridian Slates in Perry County.—This lower Meridian group, although generally thicker than the overlying Meridian sandstone, is very imperfectly exposed in the district before us. The usual position of its outcrop being on the flank of the ridges capped by the sandstone, the debris of that formation is very apt to conceal it. The most satisfactory exhibition of it met with is in the N.W. corner of the county, on the banks of a stream near the Susquehanna, 6 miles above Liverpool, where all these rocks are lifted into view by the Tuscarora Mountain axis. The mass at this point consists chiefly of dusky calcareous sandstone, characterised by its usual fossils. Its thickness is about 80 feet, being at least five times that of the Meridian sandstone. It would seem to be thinner in the interior of the county, and with the other adjoining rocks to disappear altogether on the S.E. side.

For the sake of convenience and brevity, I shall not attempt to trace its outcroppings separately from those of the Meridian sandstone, with which it is always in contact, and through the conspicuous exposures of which we possess an infallible clue to its range and position in the county.

Meridian Sandstone in Perry County.—The Meridian sandstone throughout Perry County is perhaps never more than 20 feet thick. Its most common character is that of a conglomerate, in which the pebbles are small, being from the size of a pea downward. The paste is a fine brown sand, often very ferruginous. The characteristic fossils accompany it, but are rarely well preserved, on account of the coarseness of the rocks. The formation often projects above the surrounding surface, in rough and conspicuous, though low escarpments—objects of notice to the curious. The departures from the character here given will be noticed in describing its several outcrops in detail.

Iron Ore.—In many parts of the county there is a peculiar variety of *iron ore* belonging to this formation. It is of a light hazel colour, and usually of a slaty cleavage, but sometimes cellular and mammilated. It is quite ponderous. I believe it has never been smelted advantageously by any of the furnaces. It is always the highest layer of the formation. It evidently belongs to the rock before us, for in some instances the pebbles are found diffused through it. It is probably an original deposit of argillaceous oxide of iron.

Meridian Sandstone, South-east Side of Pfout's Valley.—The chert beds of the limestone group occur in the S.E. side of Pfout's Valley, along the S.E. flank of Wildcat Ridge, near its base ; but the Meridian sandstone is either absent or extremely thin. The strata here dip 60° S.E. Below Millerstown, on the edge of the village, we meet with indications of the Meridian sandstone and slate, while the chert of the next group is well marked. This latter crosses the Juniata to range along Racoon Valley.

Racoon Valley.—The Meridian sandstone has scarcely an existence in this valley. A bed of calcareous sandstone, with large fossils, was observed at one point. Its position is near the base of Racoon Ridge, and its dip 45° — 50° S.E.

Meridian Sandstone North-east of Ickesburg.—Towards Ickesburg the sandstone becomes more evident, being a few feet of a fine conglomerate or coarse grit. It is thrown into two synclinal points or tongues, by the second and third anticlinal axes, which end a mile or more to the N.E. of Ickesburg. The formation saddles the third axis more than 2 miles N.E. of Ickesburg, and South-east-dipping strata stretch thence S.W. with much uniformity to Buffalo Creek, below Linn's Mill, a distance of 5 miles. It passes about half a mile S.E. of Ickesburg, occupying the S.E. flank of a low ridge of the Pre-meridian limestone, ranging to the N.W. of the much higher ridge of the Cadent grey sandstone.

Meridian Sandstone on the Fourth Anticlinal Axis.—This axis elevates the formation on the S.W. side of Buffalo Creek, a mile and a quarter below Linn's Mill, and on the N.W. side a synclinal belt is separated, embracing the Cadent black slates, reaching perhaps a mile S.W. along the ridge of the limestone.

The belt of Meridian sandstone S.E. of the fourth anticlinal axis ranges in a straight line S.W. for 4 or 5 miles, until it enters the ridge between Andersontown and Conecocheague Mountain. It passes a few hundred yards N.W. of Bixler's Mill, forming with the upper strata of the limestone a low ridge. The iron ore of the formation is frequently seen, but it has too much silicious matter in its composition to be of any value.

Meridian Sandstone in the Ridge three-fourths of a mile North-west of Andersontown.—The ridge N.W. of Andersontown is a double synclinal axis of the Pre-meridian and Meridian rocks ; the Meridian sandstone occupies its summit in two narrow synclinal belts, which, towards the N.E., embrace small portions of the Cadent slate. Fragments of the sandstone strew the surface in great quantity. The rock is here a fine conglomerate, and is abundant on the surface. The North-western-dipping outcrop of the more S.E. of the synclinal belts, traced to the N.E., passes S.E. of Bixler's Mill, 2 miles N.E. of which it saddles the sixth anticlinal axis, and then, with a S.E. dip, ranges three-fourths of a mile S.W., on the S.E. side of the axis, and terminates in a barren district of considerable extent, where it is spread out in a nearly horizontal position, by the flattening of the seventh anticlinal axis.

The sandstone from the point where it is first developed by the sixth anticlinal, extends S.W. for nearly a mile, flanking each side of a ridge of Pre-meridian limestone, called in the neighbourhood Sandy Ridge. This terminates at Bryner's Run, some distance below Bixler's Mill. The iron ore is found on it abundantly.

Meridian Sandstone in Limestone Ridge.—The Half-Fall Mountain anticlinal axis (tenth) throws up the Meridian sandstone on the N.E. side of the Juniata at the Falls, where it may be seen on the road with the Cadent cement layers reposing on it. It is immediately separated into a double line of outcrop by the elevation of the limestone and Surgent shales. The formation on the S.E. side of the axis, with a perpendicular dip, or nearly so, extends for 3 miles S.W., lying in the mass in ridges one-third of a mile S.E. of Caroline Furnace.

About 3 miles from the river, and 1½ miles S.W. of the Furnace S.E. of the ridge of Cadent sandstone, the ninth anticlinal axis originates and develops the Meridian sandstone, separating on its S.E. a narrow synclinal belt, which extends thence to Bloomfield, occupying the very crest of the limestone ridge. This is not, perhaps, more than twenty or thirty yards wide, along its whole course. The sandstone has been swept away by denudation S.E. of Juniata Furnace for one-fourth of a mile or more. Its position can be well ascertained throughout. There are numerous excavations upon it, made in search of iron ore,—some, for example, a mile and a half S.E. of Newport. The ore is no longer wrought. It has the usual characters, being distinguishable by its light-brown colour. If the Meridian slates are embraced by this synclinal axis, they can only be in a very narrow and shallow belt. The Meridian sandstone is much strewn in fragments on the surface. The ore is 12 or 18 inches thick, and lies on the upper bed of sandstone.

Meridian Sandstone North-west of the Ninth Axis.—The sandstone on the N.W. of the ninth axis ranges with a steep dip on the N.W. side of the Limestone Ridge, separated 300 or 400 yards from the synclinal belt. It passes S.E. of the Juniata Furnace near the Ore Bank. Its surface is level, and its fragments cover the ground.

Meridian Sandstone, Eighth Anticlinal Axis.—About a quarter of a mile S.W. of Juniata Furnace, the eighth axis develops the Meridian sandstone, and then the Pre-meridian limestone appearing, a synclinal belt of the former is insulated. This embraces, in its shallow trough, the Cadent older black slate, which, ranging S.W., lies half a mile N.W. of Bloomfield, on the N.W. side of the Limestone Ridge. It ends about 1½ miles W. of Bloomfield. The ore of the Meridian sandstone is visible on the surface along its course.

Meridian Sandstone North-west of the Eighth Anticlinal Axis.—The Meridian sandstone N.W. of the axis ranges for 13 miles S.W., with uniform N.W. dip of 40°. It occupies the N.W. flank of the limestone ridge on the S.E. side of a little valley of the Cadent black slates. It terminates to the S.W., by being spread out over the flattened extremity of the seventh axis, uniting with the same formation as described in a previous section. This takes place on the S.W. side of Bryner's Run. The formation is at that point more than a mile wide from N.W. to S.E., being on the N.E. flank of the ridge, and stretching across the valley 2 miles S.E. of Andersontown. The ore at the top of the formation exists along the hill thus traced.

Meridian Sandstone South-east of Bloomfield.—The South-east-dipping strata of the sandstone form a ledge of rocks in the river called the Juniata Falls. Followed from the Juniata, they extend in a direction about S. 60° W. for 14 miles. For several miles from the river the formation is on the S.E. flank of a ridge separated from the Mahanoy Ridge by a ravine. Thence S.W. to the end of the Mahanoy Ridge it has the same position nearly to its N.W.

base. The dip is steeply S.E., and the outcrop is usually levelled, but it sometimes stands above the surface like a wall. This is the case near the gap E. of Bloomfield. The *iron ore* accompanies it throughout.

Where the main Mahanoy Ridge of the Cadent sandstone terminates, a mile and a quarter E. of Elliotsburg, a lower ridge starts from its N.W. base, and extends 2 miles further S.W. This, for a mile and a half, is simply a continuation of the Meridian sandstone flanking the limestone. It dips S.E.

Opposite Elliotsburg, the *Eleventh Axis* originates S.E. of the ridge, and gives it a synclinal form, the Meridian sandstone capping it for a short distance.

The Meridian Sandstone saddling the Twelfth Axis.—Half a mile S.W. of the Perry Furnace Ore Bank the South-east-dipping strata run S.W. for half a mile, and then the formation returns for about one mile N.E., with a N.W. dip to arch over the twelfth anticlinal axis, there being thus a synclinal axis embracing the Cadent black slate.

Folding over the twelfth anticlinal axis, the formation passes S.W., with a S.E. dip for three quarters of a mile, meeting the same formation dipping in an opposite direction from the thirteenth anticlinal axis. This synclinal axis lies in the centre of a broad hill, one mile or more S.E. of Elliotsburg. It embraces the Cadent black slate. The iron ore of the Meridian sandstone exists in it in a stratum at least 12 inches thick, being the highest layer.

Meridian Sandstone on the Thirteenth Anticlinal Axis.—The formation ranges on the S.E. side of the thirteenth axis with a steep inclination forming the low ridge, on which the ore-banks formerly belonging to Rice and Loy are situated. Traced from the ore-banks S.W., it passes Bell's Hill, on the E. side of which it folds round, taking a synclinal position, and ranges N.E. to Perry Furnace, a distance of 4 miles, with a dip 45° N.W. This North-west-dipping zone is a quarter of a mile N.W. of McAffee's Fulling Mill, and forms the N.W. flank of a low sandy ridge stretching thence to Perry Furnace.

Meridian Sandstone on the Fourteenth Anticlinal Axis.—The Meridian sandstone saddles the fourteenth axis at Perry Furnace, and the belt on the S.E. ranging from that point, unites a mile further S.W. with the same formation N.W. of the fifteenth anticlinal axis, and the two ranges form a narrow synclinal belt enclosing the Cadent slates. This forms the central part of the low ridge extending from Perry Furnace to McAffee's Fulling Mill, where it is well exposed. From McAffee's Fulling Mill it runs a mile further S.W., forming the crest of the ridge N.W. of Landisburg, opposite which place it ends. This belt is about 100 yards wide.

S.E. of the *Fifteenth Anticlinal Axis*, it lies at the base of the high ridge of Cadent sandstone S.E. of Perry Furnace. Traced S.W., it folds round and takes a synclinal form, producing, with the Pre-meridian limestone, the hill immediately N.E. of Jenkin's Mill, which encircles the extremity of the ridge of Cadent sandstone, separated from it by a little area of the Cadent black slate.

Meridian Sandstone in Dick's Ridge Anticlinal Axis.—Elevated by the *Sixteenth* or N.W. axis of Dick's Ridge, the formation is seen on the road to Bellows, a mile and three-quarters from Bloomfield, S.W. of which point it separates into two zones by the converging of the Pre-meridian limestone. These unite again over the limestone 4 miles distant, and half a mile S.E. of Perry Furnace. That on the S.E. composes, with strata thrown into an opposite dip by the seventeenth anticlinal axis, a narrow synclinal belt. The formation thus traced on each side of the sixteenth axis, with the intervening limestone, forms the N.W. and highest portion of a broad ridge which extends from the end of Dick's Ridge south-west for 4 miles.

From the point where the Meridian sandstone folds over the S.W. extremity of the sixteenth anticlinal axis, which is a little S.W. of the Furnace Stream at the S.E. base of the ridge of Cadent sandstone, the Meridian sandstone, with a N.W. dip, being a continuation of the S.E. side of the synclinal axis, extends S.W. until it meets strata dipping in an opposite direction to form together the hill before noticed immediately N.E. of Jenkin's Mill. This belt has a steep dip, and lies close to the base of the high ridge of Cadent sandstone S.E. of Perry Furnace.

The iron ore of the Meridian sandstone is seen abundantly on the surface along the outcrop.

Meridian Sandstone on the Seventeenth Anticlinal Axis, or Middle Axis of Dick's Ridge.—The seventeenth axis develops the Meridian sandstone immediately S.W. of the end of Dick's Ridge, and the limestone emerging, the North-west-dipping strata unite in forming the slender synclinal axis before spoken of, and on the subsidence of the sixteenth anticlinal axis, the sandstone continues as described, 3 miles further to the point near Jenkin's Mill.

The South-east-dipping range of the sandstone flanks the S.E. side of the broad ridge extending S.W. of Dick's for half a mile, when meeting the same formation, elevated by the eighteenth anticlinal axis, a slender synclinal belt is formed, which runs about a mile and a half further S.W., ending in a point opposite Saddler's Limekilns.

The Eighteenth Anticlinal Axis.—This line of elevation is saddled by the Meridian sandstone at a point a mile and a half S.W. of the Bloomfield and Bellows Road, near the N.W. base of a high ridge of Cadent sandstone, which, prolonged S.W., is the Pisgah Hill. The strata of the N.W. side terminate as we have seen; those on the S.E. extend 5 miles S.W., with a uniform dip of 30° to 40° S.E., passing a short distance N.W. of Gibson's Mill. The formation flanks the S.E. side of a low ridge separated from the higher ridge of the Cadent grey sandstone by a narrow valley of Cadent black slate, in the S.W. portion of which flows Sherman's Creek, in its course below the *Warm Spring.*

Meridian Sandstone on the Nineteenth Anticlinal Axis.—A mile and a quarter below the Warm Spring, the nineteenth axis elevates the sandstone on the N.W. side of Sherman's Creek. The formation N.W. of the axis unites with the belt just described, forming a narrow synclinal ridge, which, embracing the Cadent slate, extends a mile and a half further S.W., composing the very crest of the Quaker Hills. It ends in a point on that hill W. of the Spring. There are several excavations upon it, instituted in search of iron ore. The ore peculiar to the formation is frequently seen on the surface.

The formation, separated S.E. of the nineteenth axis, lies along the base of the Quaker Hills, and is frequently washed by the creek. It dips 30° S.E. The Warm Spring is upon the junction of this rock and the black slate.

The Warm Spring is not warm, nor has it anything peculiar properties.

The Meridian sandstone extends from the Warm Spring, nearly 3 miles further S.W., to its termination in a synclinal knob half a mile S.W. of Oak Grove Furnace, retaining to this point an uniform S.E. dip. It composes the crest of the hill, and on this hill the main ore-bank of the Furnace is situated.

Meridian Sandstone at the Base of the Blue Mountain.—At the Susquehanna Water-Gap the Meridian sandstone has no existence. It is first observable a short distance W. of Sterrett's Gap, where it is of very trivial thickness. Its strata are perpendicular. Traced to Perry Furnace it assumes a steep N.W. dip, and recedes slightly from the mountain, forming a low ridge or ledge at the base of the higher ridge of the Cadent sandstone N.W. of it. At Oak Grove Furnace it receives a small inflection, the short axis formerly noticed causing a short synclinal point to project Eastward near the Furnace. The formation continuing N.W. of the short axis unites with the same stratum traced from the Warm Spring half a mile S.W. of the Oak Grove Furnace.

It is worthy of remark that some of the strata of this formation, at the base of the Kittatinny or Blue Mountain, are composed of rather large pebbles, which is never the case in the N.W. part of the county.

FIG. 64.—From Limestone Ridge to Pisgah Hill.

FIG. 65.—From Shade Mountain, 5 miles S.W. of Freeburg, to mouth of Mahantango Creek.

FIG. 66.—From Shade Mountain, 5 miles N.E. of the Juniata, to Tuscarora Mountain, 4 miles S.W. of Thompsontown.

FIG. 67.—From Shade Mountain through Mifflintown to Tuscarora Mountain.

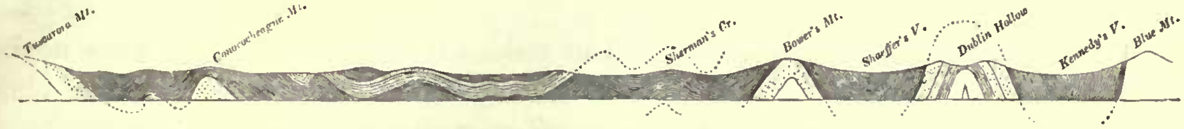


FIG. 68.—From Tuscarora Mountain, 4 miles S.W. of Run Gap, to Blue Mountain, S.E. of Kennedy's Valley.

CHAPTER IV.

CADENT AND VERGENT STRATA IN PERRY COUNTY.

COMPOSITION.

THE Cadent and Vergent series in this district are widely distributed, and are important moreover for the thickness of their general mass, and the deviation from the prevailing composition exhibited by one of the principal formations. The formations do not all exist here, there being no traces of either the Cadent upper black slate (Genesee, N.Y), or Vergent flags (Portage, N.Y.), rocks which, further to the N.W. especially, possess such a conspicuous thickness.

Cadent Older Black Slate.—This formation, so remarkable for the steady retention of its characteristic features and thickness, and for its wide diffusion in the United States, is nowhere more interesting than in the district now under review. The body of the rock is as usual a black carboniferous fissile slate, but it contains subdivisions which deserve a more special mention. It properly contains three members : these in the ascending order are,—

First, A mass of buff-coloured and grey calcareous shales, with several minute fossils. Its thickness at the Half-Fall Mountain is 25 feet.

Second, Argillaceous limestone of a light greenish colour, alternating with greenish shale. This contains several fossils,—at the Half-Fall Mountain *Atrypa limitaris,* &c., &c. Its thickness there is 20 feet.

Third, Black fissile carbonaceous slate, having the usual small fossils. Thickness in the same locality about 180 feet.

The total thickness of the formation is about 225 feet, and this may be considered as nearly its maximum for the region. At the base of the Kittatinny Mountain, on the Susquehanna, the group is much thinner. The argillaceous limestone preserves its aspect and thickness with little change over the whole county, though it does not exist at the Susquehanna in the base of the Kittatinny Mountain.

Immediately above the limestone there is a bed of iron ore, identical in quality and position with the bed seen extensively in Juniata and Mifflin counties. In its unaltered state it is a lead-coloured protocarbonate of iron, and when changed by atmospheric action is a dark brown hydrated oxide, with a cellular structure. The stratum does not appear to be completely continuous; at least, it could not always be discovered on the surface in the places where it should outcrop.

In some of the narrow synclinal troughs, this ore is absent in consequence of its removal by denuding floods, which have in these localities left only the very lowest beds of the black slate in the basin.

Cadent Shales.—This member of the Cadent series exhibits in the district some marked deviations from its usual type. Thus, instead of consisting mainly of olive, grey, and bluish argillaceous shales, it here wears the aspect of a dark greenish-grey and rather coarse sandstone, with occasional massive beds of a silicious conglomerate and whitish sandstone. It has numerous hollow pits, produced by the removal of its large fossils, the chief species of which is the *Delthyris mucronata.* The formation is thickest and of coarsest composition on the S.E. side of the county, becoming both thinner and finer-grained or more argillaceous towards the N.W. Wherever it outcrops, it forms, from its relative indestructibility, a high ridge, and is thus the chief cause of the numerous regular and continuous ranges of hills which diversify the interior of the county, separating it into so many subordinate valleys.

Among the more conspicuous of the ridges of this grey sandstone are the Half-Fall Mountain, Racoon Ridge, Dick's Ridge, Mahanoy Ridge, Pisgah Hill, &c.

Wherever the stratum crosses either of the rivers, it produces "rapids" or low "falls." It has a thickness of about 800 feet at the base of the Kittatinny Mountain on the Susquehanna.

Vergent Shales.—The Vergent series exhibits characters in Perry County which deviate little from those which generally distinguish the formation. It admits, as usual, of a subdivision into two members.

The first of these (ascending), and by far the largest portion of the mass, consists of olive, grey, and bluish shales, alternating with beds of grey sandstone. The weathered fragments are frequently brownish or dark grey. Within 200 or 300 feet of the bottom is a very dark thin slate, occasionally mistaken for a coal slate.

The whole of this division is from 1600 to 1800 feet thick at the Half-Fall Mountain.

The second and upper member of the group consists of a reddish-brown shale and sandstone, alternating with grey shale and sandstone. This portion has a thickness of from 600 to 800 feet.

The entire thickness of the series is here about 2400 feet.

It contains the well-known fossils of the formation, but these are generally in the state of casts, from long filtration of water through the rock.

This mass generally produces an irregular rolling surface, and furnishes a rather meagre soil.

GEOGRAPHICAL DISTRIBUTION OF THE CADENT AND VERGENT ROCKS IN PERRY COUNTY.

We may obtain a general idea of the distribution of the Cadent and Vergent rocks by considering them as forming two wide basins embracing all the higher formations up to the Umbral red shales inclusive, and cropping out successively in each basin towards the S.W., until they encircle the S.W. pointed extremities of the Ponent rocks in both basins, and occupy the heads of the basins exclusively. The numerous anticlinal axes which exist in Sherman's Valley arise in many instances within the borders of the basins of the Cadent and Vergent rocks, and pass out S.W. by elevating lower formations, separating thus in each instance a pointed synclinal belt or tongue from the main body.

Cadent and Vergent Rocks in Wildcat Ridge and Valley.—Wildcat Valley lies between the Susquehanna at Liverpool, and the Juniata below Millerstown. It is 2½ miles wide, and bounded S.E. by Buffalo Mountain, and S.W. by Wildcat Ridge. It is composed entirely of the Cadent, Vergent, and Ponent formations, with a S.E. dip.

The Cadent rocks form its N.W. side, the Cadent grey sandstone being in Wildcat Ridge, and dipping 50° S.E. The boundary of the Vergent and Ponent series passes from the Susquehanna 2 miles above Liverpool to the Juniata at the Dam below Millerstown, the Vergent shales forming a hilly surface with a thin soil.

Wildcat Ridge is continuous, steep, and rugged, separating Pfout's Valley from Wildcat Valley. Its N.E. end is about 2 miles from the Susquehanna, where the strata composing it saddle the N.E. extremity of the Tuscarora Mountain anticlinal axis, and the tract of Cadent and Vergent rocks we have been describing is united with that of the same formation in Juniata County lying S.E. of the George's Valley axis at the mouth of the West Mahantango Creek.

Wildcat Ridge is highest towards Millerstown, S.W. of which place its strata are crossed by the Juniata. The N.W. limit of the Cadent sandstone is near its N.W. base. There is no iron ore discoverable along this ridge in the Cadent black slate, in the position in which we should look for it.

Cadent and Vergent Rocks in Racoon Ridge, and the District immediately South-east of it.—This is a continuation of the belt of country just described, traced S.W. from the Juniata in Racoon Ridge, and the country for 1½ miles S.E. of it.

Racoon Ridge bounds Racoon Valley on the S.E. It extends with the same height and aspect from the Juniata 8½ miles S.W., when two anticlinal axes, emerging from the S.W. into higher formations, produce an effect in the ridge by which it is thrown considerably to the S.E.; and although it continues on S.W., it no longer receives the same name. Racoon Ridge is straight, and perhaps 200 feet high, and nearly half of a mile wide through the base. It is steep and barren, and cut by two gaps. It consists entirely of the Cadent grey and olive sandstone, dipping 40° S.E. The N.W. limit of that formation is at its N.W. base. No *iron ore* was detected in the Cadent black slate in its usual position.

The Vergent Shales on the S.E. of Racoon Ridge form a zone nearly 1½ miles wide, limited on the S.E. by the Ponent rocks, as far as the point where the latter cease to lie in the synclinal axis opposite the end of Racoon Ridge properly so called, and about 9 miles from the Juniata river. It there coalesces along the main synclinal line with the other belt of the same formation lying further S.E. This united tract forms the N.W. part of the wide district of Cadent, Vergent, and Ponent rocks between Racoon Valley on the N.W. and the Limestone Ridge on the S.E. It is drained by the Buffalo Creeks. Its surface is hilly, and the soil is rather destitute of fertility. The S.E. limit is pretty well marked by an indistinct ridge called sometimes Hominy Ridge, which owes its existence to a massive stratum of yellowish argillaceous sandstone in the upper part of the Vergent shales. The dip of the strata towards Racoon Ridge is about 40° S.E., becoming gentler towards the middle of the basin. The third anticlinal axis originates in this belt about 5 or 6 miles from the Juniata, near the S.E. base of the ridge. It elevates the Cadent sandstone so as to form a short ridge confounded with Racoon Ridge, which passes S.E. of McKenzie's Mill, and ends where the axis passes out into the Cadent black slate, producing the effect in the ridge before mentioned. The second anticlinal axis does not pass so far N.E. in the Cadent rocks as to influence the sandstone. It separates only a short point of the lower black slates from the main body on the N.W. side of the axis. This is about 2 miles N.E. of Ickesburg. It is synclinal, but to a very trifling extent.

Another synclinal tongue is separated by the third anticlinal axis, lying between it and the second. It is not more than three-quarters of a mile long, and 200 or 300 yards wide, ending in a point 1½ miles N.E. of Ickesburg. *Iron ore* of the usual character, the thickness of which is not known, has been discovered in it. It lies between the two low ridges of the Meridian sandstone, not far from the end of the belt.

Nearly opposite the separation of the belt we have described, from the main body of the Cadent and Vergent rocks, the general basin of the Ponent rocks ends, and the two encompassing zones of the lower strata unite. We proceed to trace that of the S.E. side, from the Susquehanna river to this point.

Cadent and Vergent Rocks between the Juniata and Susquehanna, above their Junction.—Between the two rivers there is a large tract of the Cadent and Vergent rocks of a quadrangular form, lying in Buffalo township, traversed centrally by an anticlinal axis, which, prolonged N.E., passes into the coal region. The N.W. boundary may be drawn from Montgomery's Ferry to the Toll-gate on the Juniata, ranging about 1¼ miles S.E. of the base of Berry's Mountain. The S.E. limit is on the Juniata, about one mile above the junction of the canals. The width of the district on the Juniata is about 4 miles, and on the other river less than 3 miles. In the middle of it a high ridge, called the Half-Fall Mountain, extends from one river to the other.

Half-Fall Mountain.—On the Juniata this ridge is about 400 feet high, and has a triple crest. Towards the N.E. it becomes somewhat lower; it is rugged, sterile, and covered with a pine forest, and is a mile wide through the base, becoming narrower towards the Susquehanna. The Half-Fall Mountain is composed of the hard Cadent grey sandstone, the representative of the Cadent olive shales. It is a broad anticlinal flexure of the unsymmetrical or normal form. On the N.W. side the strata are perpendicular, and on the S.E. they dip 30° S.E. The perpendicular strata are confined to the N.W. flank, for in the crest the rocks dip S.E. There is a tendency in the South-east-dipping strata to form a double crest for several miles N.E. of the Juniata. (See Map and Sections.)

The limestone of the Cadent black slate may be seen on the turnpike road at the S.W. end of Half Fall-Mountain at the Juniata, being but a short distance above the Pre-meridian sandstone. It is a tolerably pure limestone.

Below the Half-Fall Mountain on the turnpike, the Cadent sandstone is again elevated by a roll forming a considerable hill.

Vergent Shales.—These rocks, S.E. of the Half-Fall Mountain, form a hilly surface thinly populated. The strata have a general dip of 30° S.E., with some contortions. They are well exposed along the Juniata at Huling's Narrows.

The belt N.W. of the Half-Fall Mountain has a nearly vertical dip, and a surface of the usual characters. At its S.W. end, at the river, the Meridian sandstone is elevated at the anticlinal axis, and the tract of Cadent rocks S.W. of the Juniata is separated into two divisions, the North-western one of which we proceed to trace.

Cadent and Vergent Rocks N.W. of the Limestone Ridge.—This belt, from the Juniata at Caroline Furnace to where it coalesces with the other belt of the N.W. side of the basin, 15 miles to the S.W., has the same general topographical features. Its North-western line, passing near the town of Newport, and thence S.W., is pretty well marked by a continuous rounded ridge called the Middle Ridge, which owes its existence to the hardness of the yellowish sandstone before mentioned as lying near the top of the Vergent slates.

The limestone ridge, as already stated, consists of two distinct crests, separated by a considerable depression. The North-western is composed of the hard Cadent sandstone dipping N.W., at the S.E. base of which runs the boundary of the Meridian and Cadent rocks. This crest or ridge, although very distinct, has no particular name. It bounds the valley of Little Buffalo Creek on the S.E.; and is steep, sterile, and broken by a number of gaps, which drain the depression between it and the Limestone Ridge proper. Its strata at Caroline Furnace dip 80° N.W., but further S.W. more gently, and opposite Bloomfield they dip 35° N.W. The Cadent black slates above the Meridian sandstone are about 300 feet thick, and in these the *iron ore* and limestone are found ranging between the limestone ridge and that just described.

Iron Ore, Juniata Furnace.—This is a bed from 8 to 10 feet thick, entirely of the brown cellular variety. It is between black slate, a few feet above the Cadent limestone, and about 100 feet above the Meridian sandstone. It dips 45° N.W. This is the only point where the ore has been discovered on this range, although it is highly probable it may be found at other places.

The ninth anticlinal axis separates a very narrow belt of a synclinal form from the main body of the Cadent and Vergent rocks. This occurs about 1½ miles S.W. of Caroline Furnace. It is short and obscure, and of no importance.

The eighth anticlinal axis also isolates a tongue of the lower slates from the main tract of Cadent and Vergent rocks. This takes place a short distance S.W. of Juniata Furnace, not more than a mile beyond which it terminates in a point. It is probable that the outcrop of the ore here takes a bend from the influence of the eighth anticlinal axis, but it does not enter the tongue of slates.

From Juniata Furnace south-west the margin of the Meridian sandstone ranges in a straight line.

The Vergent shales lying between the *Middle Ridge* and the ridge of the Cadent sandstone, compose a considerable portion of Juniata Township. It is traversed by Little Buffalo Creek, has the usual characters of the formation, and merits no particular notice. The dip here is more gentle towards the synclinal line than at the Juniata.

Where the Ponent rocks terminate, the two tracts of Vergent strata on each side of them meet in one synclinal basin, which is 3½ miles wide. This is crossed by the road from Ickesburg towards Landisburg. A ridge of the Cadent grey sandstone on each side encircles a general valley of the Vergent shales.

Following the formation S.W., this simplicity of structure does not continue. The fourth anticlinal axis, originating in its N.W. border a mile or more S.E. of Ickesburg, passes out, elevating the Meridian sandstone, and a short synclinal point of the Cadent rocks is separated from the main body to the S.E. of it. It is not more than half a mile in length. This occurs at Buffalo Creek, where it enters the ridges 1¼ miles below Linn's Mill, and 3 miles S.W. of Ickesburg,

From the preceding point S.W., the tract continues undivided for perhaps 2 miles, and the distance between its N.W. and S.E. edges is nearly 2½ miles. It is not, however, a simple synclinal trough, but is traversed by the N.E. extremity of the sixth anticlinal axis, which, followed S.W., elevates the Meridian sandstone, and divides the Cadent and Vergent tract into two synclinal belts. Of these, the North-western and narrowest is about half of a mile wide where it separates, growing narrower to the S.W. The dips are gentle. This belt admits the Cadent grey sandstone for a mile or more in the form of a ridge. Bixler's Mill lies on this belt. A short distance S.W. of Bixler's Mill, and nearly 2 miles from the origin of the belt, it is subdivided by the elevation of the Meridian sandstone—lifted by the fifth anticlinal axis—into two narrow synclinal ridges. Along the centre of these the Cadent black slate is prolonged a mile or two. These are the ridges which lie between Andersontown and the Conecocheague Mountain. We could not find any indications of the iron ore in this quarter, although the limestone layers are frequently exposed.

Cadent and Vergent Rocks S.E. of the Sixth Anticlinal Axis.—The widest division of the Cadent and Vergent tract lies S.E. of the sixth axis. It forms a gentle synclinal axis, the rocks in the centre of which are perfectly flat for a mile or more across. This is due to the flattening of the seventh anticlinal axis, which dies away, as it were, under the S.W. extremity of the general synclinal basin of the Vergent and Ponent series. The Cadent limestone crossed by the road from the Centre church to Waterford is exposed in a horizontal position for more than a mile, although the stratum is not more than 8 or 10 feet thick. The lowest shales of the Cadent black slate extend perhaps half a mile S.W. of the road, lying in an area enclosed by a ridge of Meridian sandstone, and crossed by Bryner's Run. The formation does not end in a narrow point, but crops out in a blunt termination more than a mile in breadth.

The Meridian sandstone, meeting from opposite sides of the synclinal basin, forms a high broad ridge or table-land, closing round the S.W. end of the general valley of the two Buffalo Creeks.

Cadent and Vergent Rocks S.E. of the Tenth Anticlinal Axis, or that of Half-Fall Mountain passing Bloomfield.—The tract of Cadent and Vergent strata separated on the S.E. by the intrusion of lower formations along the Half-Fall Mountain axis is on the Juniata 2½ miles wide, extending from the Juniata Falls south-eastward, with a prevailing S.E. dip. Spread out to the S.W., it forms a large portion of Rye and Tyrone townships, and is subdivided in an extraordinary manner by the origin of numerous anticlinal axes within its borders, which pass out S.W. into lower formations.

The belt extends undivided from the Juniata for 7½ miles S.W. to the road crossing from Bloomfield to Billow's, becoming wider in consequence of the sixteenth, seventeenth, and eighteenth anticlinal axes, so that on the road mentioned the whole tract is 4 miles wide. A short distance further S.W. these axes elevate the Meridian and Cadent formations. Its N.W. limit is along the N.W. base of Mahanoy Ridge, and its S.E. edge ranges parallel with, and about 1½ miles from the Cove Mountain.

Dick's Ridge.—This ridge occupies the middle portion of the belt, rising 2 miles from the Juniata, and stretching thence 5½ miles to the road by Billow's. It is composed of the Cadent grey sandstone. The N.E. portion for 4 miles is in the form of a simple anticlinal wave (the sixteenth axis), the rocks of which on the N.W. are perpendicular, and on the S.E. inclined at an angle of 45° S.E. Further S.W., however, the seventeenth and eighteenth axes throw up the Cadent sandstone, and make the N.W. end of Dick's Ridge very broad and high, the axes being so close together as not to admit of any synclinal valleys between them.

Dick's Ridge is cut by a gap, through which the Little Juniata Creek passes above Montebello Furnace, and it forms, with the Mahanoy Ridge, a narrow synclinal valley of the Vergent shales, in which the Little Juniata Creek flows.

Mahanoy Ridge.—This ridge stretches from the Juniata River at the Falls for 13 miles South-westward, bounding the narrow valley of Levant rocks, in which Bloomfield is situated, on the S.E. Its height is uniform (150 or 200 feet), its slopes are steep, and it is barren and uncultivated, and broken by five or six gaps. It has a slight curve S.W. of Bloomfield, and consists of the Cadent sandstone dipping steeply to the S.E. Its Western base marks the limit of the series.

Iron Ore along the N.W. Base of Mahanoy Ridge.—There are several excavations situated between 2 and 3 miles S.W. of Bloomfield. The ore, which was at one time taken to Juniata and Perry furnaces, consists of both the altered and unaltered varieties, and lies perhaps 80 feet above the top of the Meridian sandstone, the strata having a nearly perpendicular dip. It no doubt exists in a continuous bed for 3 or 4 miles.

The third anticlinal axis of Dick's Ridge elevates the Meridian sandstone immediately S.W. of the end of the ridge, and separates the Cadent formations into two general belts, besides admitting two short tongues of the Cadent lower black slates in the synclinal axis between them. Of these divisions I shall describe the North-western first.

Where this is first separated, it is about 1¼ miles wide, and extends undivided for 3½ or 4 miles further S.W. to Perry Furnace. The Mahanoy Ridge occupies the N.W. border of the tract, and a much lower ridge of the same Cadent grey sandstone its S.E. margin. The centre is studded with irregular hills, and is traversed by the N.E. extremities of the thirteenth and fourteenth anticlinal axes. The former of these (thirteenth) lifts the Meridian sandstone into a ridge close along the S. side of the Mahanoy Ridge, which is called by some *Cramley's Hill;* and the latter (fourteenth) elevates the same formation into an anticlinal ridge, which immediately separates into the ridges seen on either side of Perry Furnace.

Cadent and Vergent Rocks S.E. of Perry Furnace.—Precisely at Perry Furnace the fourteenth anticlinal axis elevates the Meridian sandstone, and one mile further S.W. the fifteenth axis originates, and brings up the same formations. A synclinal belt of Cadent rocks more than half of a mile wide is thus separated on the S.E. of these axes. It contains the Cadent grey sandstone, which forms a high pine-covered ridge extending from the Furnace 2½ miles further S.W., ending about a mile N.E. of Jenkin's Mill.

Cadent and Vergent Rocks between the Fourteenth and Fifteenth Anticlinal Axes.—An exceedingly narrow belt of the Cadent black slate (20 or 30 yards wide) lies for 3 miles in the synclinal axis between the fourteenth and fifteenth axes. This is seen exposed at M^c^Affee's Fulling-Mill 1½ miles N.E. of Landisburg.

The sixteenth or North-western axis of Dick's Ridge terminates in the Cadent black slate along the S.E. base of the ridge S.E. of Perry Furnace. A short point of the slate is probably separated from the belt, re-entering the synclinal axis S.E. of it. We observed no *iron ore* anywhere in the Cadent tract just described.

Cadent and Vergent Rocks N.W. of Perry Furnace.—The Cadent and Vergent strata cover all the area between the axes in the Meridian and Pre-meridian rocks at Perry Furnace and the Valley of Bloomfield. The middle of the space they occupy is traversed by the thirteenth anticlinal axis lifting the Cadent sandstone. The whole belt is a mass of sterile ridges. Tracing the thirteenth axis South-westward, it develops the Meridian sandstone about 1¾ miles W. of Perry Furnace, again dividing the Cadent tract. The district S.E. of the axis is a simple synclinal trough of Cadent rocks dipping 60° S.E. and 40° N.W., and more than half a mile wide. It embraces the Cadent sandstone, which, as usual, forms a high ridge. It is this ridge which ends half a mile N. of *M^c^Affee's Fulling-Mill,* and S.E. of Oak Grove ore-bank on Loy's farm.

The Cadent lower black slate, containing the ore and limestone, spreads round the end of the ridge, and is hemmed in by a ridge of Meridian sandstone.

Iron Ore of the Cadent Black Slate.—There are three excavations on the South-east-dipping strata of this synclinal axis on the farms of Messrs Rice and Loy. The ore has a steep dip. It is used at Oak Grove Furnace, and has all the usual characters. No doubt it might be discovered S.W. of the openings mentioned, as it folds round the end of the synclinal axis to assume the N.W. dip.

Cadent and Vergent Rocks N. W. of the Thirteenth Axis.—The Cadent sandstone, separated on the N.W. of this axis, unites with that of the Mahanoy Ridge, forming the synclinal knob which ends about $1\frac{1}{4}$ miles E. of Elliotsburg, being the S.W. extremity of Mahanoy Ridge. From a point S.W. of the end of this ridge, the eleventh anticlinal axis, here originating, passes S.W., and a quarter of a mile S.E. the twelfth rises in the Cadent and Vergent rocks, to range parallel with it. These axes do not influence the Cadent grey sandstone, but the black slates pass into the synclinal axis between them.

The synclinal point of Cadent slate between the eleventh and tenth anticlinal axes is quite insignificant. It is separated not far S.W. of the most S.W. of the Perry Furnace ore-banks. In the synclinal axis of the eleventh and twelfth anticlinal axes, the slates extend for half a mile S.W., lying in a hollow between two ridges of Meridian sandstone. A branch of Moretour's Run flows in this belt. The bed of *iron ore* probably enters with the slates for a short distance.

The Cadent black slate also forms a short wedge-shaped belt in the synclinal axis of the twelfth and thirteenth anticlinal axes, lying on the N.E. end of a broad hill of Meridian sandstone and Pre-meridian limestone.

Iron Ore of the Cadent Black Slate.—An ore-bank has long been worked for the Perry Furnace about a mile E. of Elliotsburg. It lies on the S.E. flank of a ridge of Meridian sandstone, which bounds the Bloomfield Valley, where the Mahanoy Ridge ends. It is chiefly of the brown cellular variety. Traced from this point to the S.E., it would probably be found to receive inflections opposite the eleventh and twelfth anticlinal axes, returning into the synclinal axes, and finally saddling the thirteenth axis three quarters of a mile S.E. of the ore-bank, becoming the same range on which Loy's and Rice's ore-banks are situated. It is highly probable that the ore exists between the points where it is or was mined.

Cadent and Vergent Rocks S.E. of the Eighteenth Anticlinal Axis.—The Cadent and Vergent belt, separated to the S.E, where the Dick's Ridge axes elevate the lower formations, consists of the entire series dipping 25° or 30° S.E. Its S.E. limit is $1\frac{1}{2}$ miles N.W. of Blue Ridge. The Cadent sandstone crops out in the form of a regular high ridge, properly a continuation of Dick's Ridge, which extends South-westward in a straight line nearly to Oak Grove Furnace, its S.W. extremity receiving the name of Pisgah Hill. It lies S.E. of the Warm Spring, and Sherman's Creek passes through a gap in it. The ridge is barren, rugged, and steep, and in some places has a tendency to show two crests. The rocks dip 30° to 40° S.E. It terminates by uniting with the ridge of the same strata, ranging nearer to the Blue Mountain, forming a rather high synclinal knob near Oak Grove Furnace. The N.W. limit of the formation is at the base of this ridge. The nineteenth anticlinal axis originates in the black slate near Gibson's Mill, at the N.W. base of the Pisgah Hill. It develops the Meridian sandstone $1\frac{1}{4}$ miles S.W. of Gibson's Mill, and about the same distance N.E. of the Warm Spring a narrow zone of slate separates itself N.W. of the main body of the formation. This extends for nearly $1\frac{1}{2}$ miles S.W. embraced in the synclinal axis of Meridian sandstone constituting the crest of the Quaker Hill. It is but 20 or 30 yards wide, and passes 400 or 500 yards N.W. of the Warm Spring. It has been exposed in several places by excavations made in search of the iron ore of the Meridian sandstone. There is no ore of the Cadent black slate discoverable along the outcrop in this quarter, although it appears to the S.W. at Oak Grove Furnace.

The Vergent shale on the S.E. of the ridge we have described, forms the usual hilly surface. It coalesces with the other tract of the same formation, ranging nearer to the Kittatinny Mountain, along the synclinal line of the Cove, by the termination of the Ponent belt, about $3\frac{1}{2}$ miles S.W. of the end of Pine Ridge. We proceed to describe the most South-eastern belt of the Cadent and Vergent rocks in the county.

Fishing Creek Valley.—Fishing Creek Valley is between the Blue Mountain and the Cove Mountain. It is 9 or 10 miles in length, extending from the Susquehanna S.W., and is from $1\frac{1}{4}$ to $1\frac{1}{2}$ miles wide. Its proper S.E. boundary is the ridge of Cadent sandstone at the base of the Blue Mountain. It lies in Rye Township, is drained by Fishing Creek, and is hilly and thinly settled.

The Cadent and Vergent strata in Fishing Creek Valley are in a perpendicular attitude. They occupy the S.E. half of the valley, the boundary of the Ponent rocks being near the centre.

The Cadent sandstone forms a high ridge, which extends from the Susquehanna to Oak Grove Furnace, a distance of 18 miles. It lies close to the base of the Blue Mountain, forming with it a slender valley, called in the neighbourhood Polecat Valley. Towards Oak Grove Furnace this becomes wider, as the ridge diverges from the mountain in connection with more gentle dips. The ridge is broken by a number of gaps, and it unites with the Pisgah Hill north-east of Oak Grove Furnace. The Vergent shales, passing S.W. of the end of Fishing Creek Valley, unite 3 miles distant along the synclinal line with the same formation, dipping to the S.E. The ridge of Cadent sandstone is called Gallagher's Ridge, opposite Sterrett's Gap.

The Cadent black slate at the Susquehanna Water-Gap is in contact with the Surgent red shale, and continues so for 7 or 8 miles S.W., when the Meridian sandstone begins to appear between them.

Iron Ore of the Cadent Black Slate near the Blue Mountain.—About 2 or 3 miles S.W. of Sterrett's Gap in Polecat Valley, the Cadent ore is found in its ordinary aspect. From thence to Oak Grove Furnace, a distance of 4 miles, we have frequent indications of it. It is here about 50 feet above the Meridian sandstone.

Iron Ore at Oak Grove.—Oak Grove Furnace is situated on the Pre-meridian limestone, brought up by a contortion or short axis, throwing the Pre-meridian and Meridian rocks into two synclinal belts, embracing the Cadent black slate with the iron ore. Of these, that on the S.E. side is the shorter, ending about 200 yards E. of the Furnace. The two ore-banks immediately N.E. of the Furnace are situated in this belt, and it is probable that, by going 200 or 300 yards N.E. along the synclinal axis, conditions more favourable for mining the ore might be found.

The main synclinal axis of the Cadent black slates, passing N.W. of the Furnace, extends for nearly half a mile S.W. of it. The principal ore-bank is on the South-east-dipping strata of this axis. It is situated on the flank of a hill of Meridian sandstone, the strata in which dip 50° S.E. The ore is about 5 feet thick. The neighbourhood of Oak Grove is abundantly supplied with this ore, which may be easily discovered by observing its relative position to the Meridian sandstone, above the top of which it lies about 50 feet.

FIG. 69.—From Shade Mountain, below Lewistown, to Tuscarora Mountain, 3½ mlies S.W. of Run Gap.

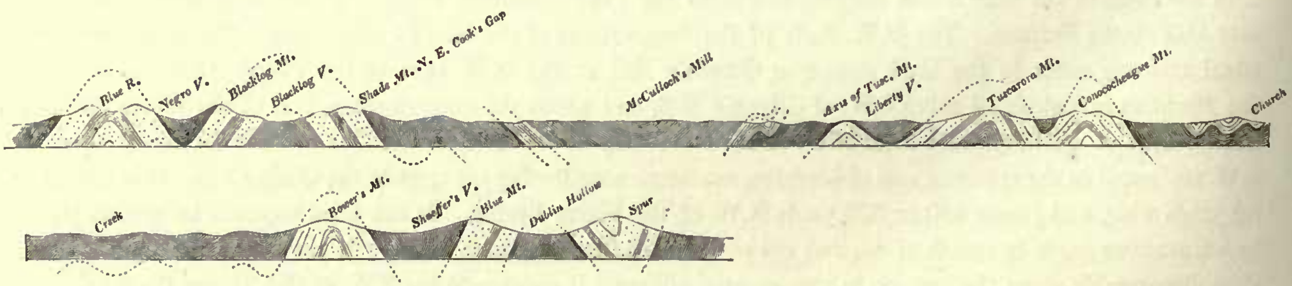


FIG. 70.—From Blue Ridge, 6½ miles S.W. of Lewistown, to Blue Mountain.

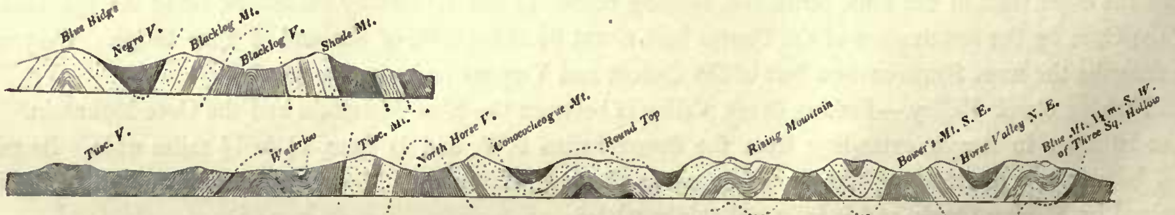


FIG. 71.—From Blue Ridge to Blue Mountain, one mile S.W. of Three Square Hollow.

CHAPTER V.

PONENT ROCKS IN PERRY COUNTY.

COMPOSITION.

The general description of the Ponent rocks in their S.E. type has been already given in the Chapter devoted to this series in its development N.E. of the Susquehanna.

GEOGRAPHICAL DISTRIBUTION.

Ponent Red Sandstone.—If we follow the Susquehanna from Liverpool to its passage through the Kittatinny Mountain, it is found to cross four belts of the Ponent red sandstone. In the two North-western of these, the rocks dipping towards a central synclinal line, the belts unite near the Juniata round the knob of Buffalo Mountain, and the formation is prolonged thence S.W. for 12 miles, ending in a point.

The two South-eastern belts, in like manner encircling the Cove Mountain, unite, and are prolonged S.W., ending in a point in Sherman's Valley. These outcrops are but extensions of the great synclinal axes of the Lykens Valley and Dauphin County coal-basins respectively.

Ponent Red Sandstone in Wildcat Valley.—The Ponent red sandstone occupies the South-eastern half of Wildcat Valley, and ascends at least two-thirds of the height of the Buffalo Mountain, round the end of which, 3 miles below Millerstown, it unites with the zone S.E. of Berry's Mountain. Its strata on the Susquehanna dip 60° S.E., and have a somewhat gentler dip at the Juniata. Its N.W. limit passes in a straight line from a point a mile N.W. of Liverpool to the dam below Millerstown. It forms a hilly surface in the valley, but no bench on the slope of the mountain.

Ponent Red Sandstone S.E. of Berry's Mountain.—The Ponent red sandstone, with a N.W. dip, forms the S.E. flank of Berry's Mountain, and a tract of country S.E. of it, extending about a mile wide from its base. A line drawn from Montgomery's Ferry to Newport, with a slight curve, would indicate its S.E. limit. On the Susquehanna it dips 70° N.W., and on the Juniata 50° N.W. It meets the same formation with an opposite dip round the end of the knob formed by the union of Buffalo and Berry's mountains, so that on the Juniata there is a regular synclinal belt, 3 miles in width, extending from the dam to Newport.

Ponent Red Sandstone S.W. of the Juniata.—This synclinal tract stretches from the Juniata 10 or more miles S.W. in the form of a sharp wedge, lying chiefly in Juniata Township. The boundaries of the formation are marked nearly by the Middle Ridge on the S.E., and Hominy Ridge on the N.W. The inclination of the strata becomes less as they recede from the river. Buffalo Creek flows through the belt for the last 8 or 9 miles of its course. The formation affords a tolerably good soil for cultivation. The Middle Ridge and Hominy Ridge owe their existence to a few hard strata of buff and grey sandstone near the top of the Vergent rocks.

Ponent Red Sandstone N.W. of the Cove Mountain.—In the neighbourhood of Duncan's Island the Ponent red sandstone extends 2½ miles N.W. of the base of Peter's Mountain. It is spread out by undulations in the strata. It occupies the South-eastern portion of the district between the Susquehanna and Juniata rivers at and above their junction, and its North-western limit is a mile or more above the head of Duncan's Island on the Juniata, and crosses the Susquehanna above Halifax.

To the S.W. of the Juniata the formation contracts in breadth, its N.W. limit being about 1½ miles from the base of the Cove Mountain, which is a prolongation of Peter's Mountain S.W. of the Susquehanna. It assumes a uniform S.E. dip of about 35°. The lower part of the group, or Ponent lower red shale, lies chiefly N.W. of Sherman's Creek. It produces a hilly surface with a thin soil.

The middle member, or Ponent sandstone, extends high up on the Cove Mountain. This contains some very hard and massive strata of red and grey argillaceous sandstone, which have offered considerable resistance to denuding action. These compose the ridge which extends from Duncannon Iron Works on the N.W. side of Sherman's Creek, the creek flowing between the Ridge and Cove Mountain in the softer Ponent upper red shale for about one mile. A mile above Duncannon the hard strata cross the creek, and occupy the flank of the Cove Mountain, producing a very distinct terrace half of the height of the mountain. This terrace is cut by a single gorge opposite Fio Forge. S.E. of Fio Forge an extensive marsh, called Stillman's Swamp, covers the terrace $5\frac{1}{2}$ miles S.W. of Duncannon. The Ponent red sandstone, ranging thus S.W. along the N.W. side of the Cove Mountain, meets with the belt which extends through Fishing Creek Valley.

Ponent Red Sandstone in Fishing Creek Valley.—The formation underlying the North-western side of Fishing Creek Valley reaches high on the S.E. flank of the Cove Mountain, where the strata are in a perpendicular position, and on the Susquehanna are overturned so as to dip 70° S.E. The inferior portion or older red shale forms throughout Fishing Creek Valley gentle hills, which are very little cultivated. The higher strata rest on the slope of the mountain, the hard beds producing a range of obscure knobs high on its flank towards the Susquehanna, and further to the S.W. a distinct terrace. The boundary between the Vergent and Ponent rocks is near the centre of the valley.

Ponent Red Sandstone S.W. of the End of Cove Mountain.—By the junction of the two belts of the formation around the S.W. end of the Cove Mountain, there is a district 4 miles in breadth, of a synclinal structure, which, contracting rapidly, terminates in a point $4\frac{1}{2}$ miles W. of Sterrett's Gap. The hard middle strata which form the terraces are prolonged $1\frac{1}{2}$ miles S.W. of the end of the Cove Mountain, encircling it with an elevated ridge called Pine Ridge.

FIG. 72.—From Jack's Mountain through Orbisonia to Blacklog Mountain.

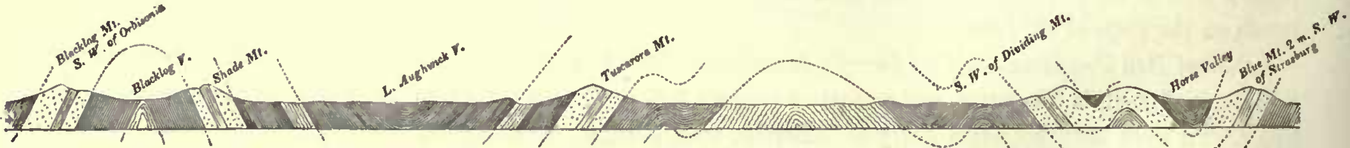


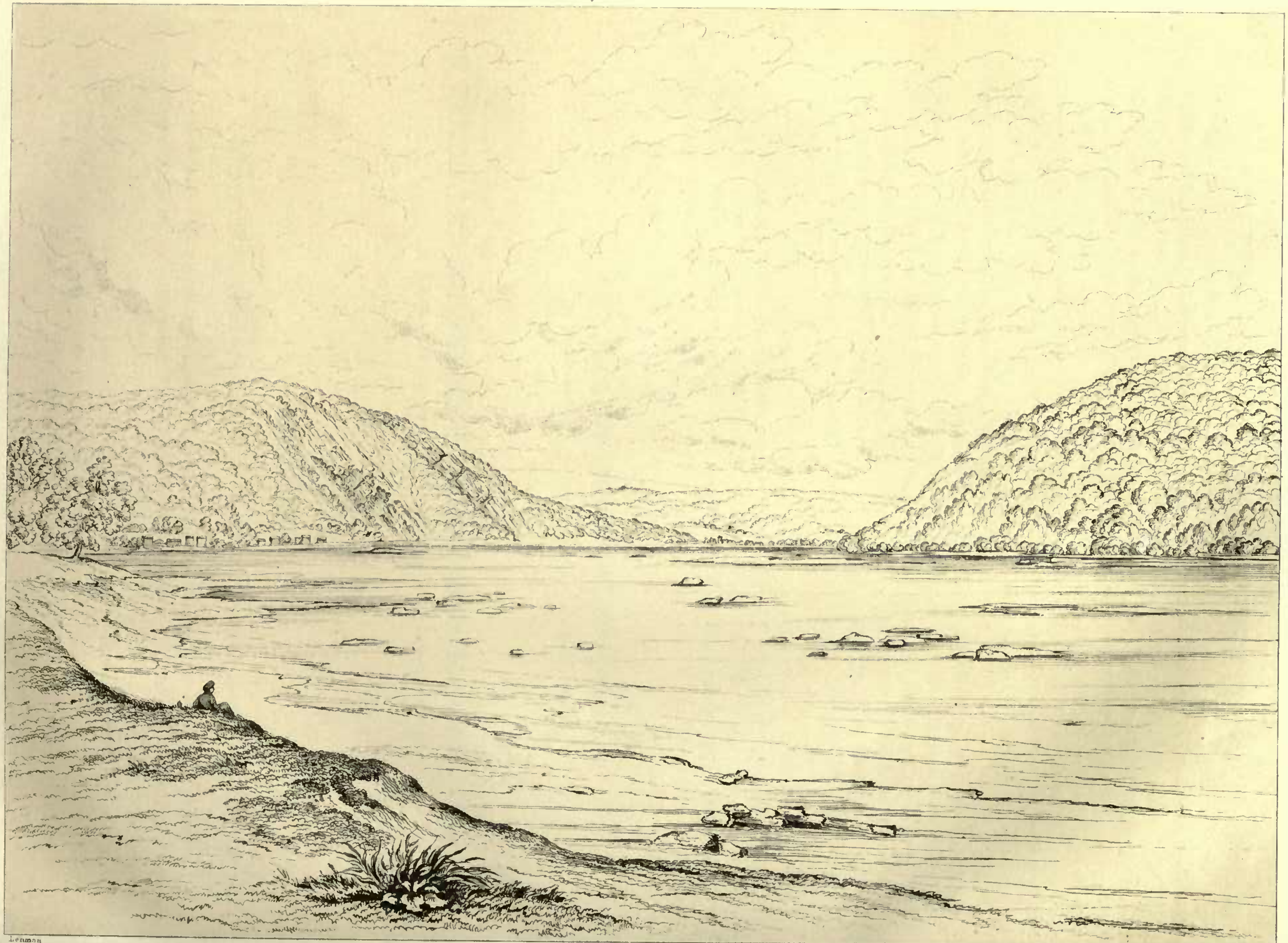
FIG. 73.—From Blacklog Mountain to Bluo Mountain, $2\frac{1}{2}$ miles S.W. of Roxbury.

CHAPTER VI.

VESPERTINE CONGLOMERATE, AND UMBRAL RED SHALE IN BUFFALO MOUNTAIN.

BUFFALO MOUNTAIN lies between Hunter's Valley and Wildcat Valley. It ranges from the Susquehanna below Liverpool to the Juniata, 3 miles below Millerstown, where it ends by uniting with Berry's Mountain in a high synclinal knob. It is of uniform height and even slopes, has a somewhat undulating line, and is cut by a gap $1\frac{1}{2}$ miles from its South-western extremity.

It consists of the Vespertine conglomerate, and is a prolongation of the Mahantango Mountain east of the Susquehanna. The strata dip at an angle of 50° S.E. on the Susquehanna, but they



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SECOND MOUNTAIN GAP, SUSQUEHANNA RIVER.

become more gentle towards the Juniata. The character of the formation cannot be readily studied in detail in this mountain, for want of good exposures. On the Hunter's Valley side the Conglomerate forms the whole flank of the mountain, the slope and dip nearly coinciding, and the Ponent red sandstone ascending nearly to the crest.

The Vespertine conglomerate is the lowest formation in the whole Appalachian system of rocks in which continuous beds of genuine coal are met with, but neither in the ridge encircling Hunter's Valley, where a fruitless attempt was once made to open a mine, nor in any other outcrop of the formation in Pennsylvania, does a regular seam of coal, even a few inches thick, occur.

GEOGRAPHICAL DISTRIBUTION.

Vespertine Conglomerate, Berry's Mountain, West of the Susquehanna.—Berry's Mountain is breached at the Susquehanna 3 miles below Liverpool, and extends thence 7½ miles Westward in a straight line, terminating and uniting with the Buffalo Mountain in the high knob overhanging the Juniata.. It bounds Hunter's Valley on the S.E. It has an inflected course, and its slopes are smooth. A mile and a half from the Juniata there is a gap opposite to that in the Buffalo Mountain. The Vespertine or lower carboniferous conglomerate of Berry's Mountain dips on the Susquehanna 70° N.W. In its lower beds there is a thin band of black slate containing some fossil plants of the coal-formation. The presence of these indications of coal led to a persevering but unavailing attempt to discover a regular seam here. All the geological conditions resemble those of the same formation in Sideling Hill on the Potomac, where much money and labour have been thrown away in digging for coal in a corresponding black carbonaceous slate.

Cove Mountain.—Peter's Mountain and the Second Mountain are both breached at the Susquehanna, Westward of which they approach until they unite and form the mountain, termed the Cove Mountain, which encircles the Cove.

Cove Mountain exhibits in its bend the form of a Gothic arch; the N.W. division—the prolongation of Peter's Mountain — is the shortest; it extends from the Susquehanna below Duncannon 5½ miles S.W., where it ends by meeting the S.E. division. Its crest is unbroken, and its S.E. flank is regular; its N.W. slope exhibits the terrace which has been already noticed.

The N.W. ridge of the Cove Mountain is composed of the Vespertine conglomerate, with a dip 45° S.E. Some thin layers of carbonaceous slate have been dug into near the river in an unavailing search for coal. A thin seam, apparently not regular, of impure coal, has been found.

The S.E. division of the Cove Mountain extends from the Susquehanna, opposite Greensburg, for about 9 miles S.W., separating the Cove from Fishing Creek Valley. It has a gentle curve to the W., undulating a little in its course. The flank next the Cove is smooth, but that on the S.E. has a terrace. In the S.E. ridge of the Cove Mountain the strata are perpendicular, and towards the Susquehanna they are even overturned, so as to dip steeply to the S.E. The conglomerate has its ordinary characters. The hard strata in the middle of the Ponent red sandstone form a series of terraces, sweeping round the end of the Cove Mountain in a curve of the same shape as that of the Cove Mountain itself.

Umbral Red Shale in Hunter's Valley.—Hunter's Valley is a triangular valley or cove enclosed by Berry's Mountain and Buffalo Mountain. It is nearly 2 miles wide on the Susquehanna, but, traced S.W., it gradually contracts in breadth until it ends by the closing of the mountain. It is occupied by the Umbral red shale in form of a synclinal basin, with dips 45° S.E. and 60° N.W. The Umbral red shale does not extend up the mountain-slopes, being bounded by its base. It terminates 4 miles from the river. The valley has a rolling surface, and is well cultivated.

Umbral Red Shale in the Cove.—The Cove is enclosed by the Cove Mountain and the river. It is about 2 miles wide at the Susquehanna, 4 miles W. of which it ends. It is a synclinal basin of the Umbral red shale. On the S.E. side of the Cove the strata are perpendicular, and at the river inverted, dipping 75° S., and on the

N.W. side inclined 40° S.E. They are bounded by the base of the mountain. The valley has a rolling surface, and is much covered by debris.

Trap Dyke.—This is an intrusion through the strata of a greenstone trap of a dark grey colour, semi-crystalline aspect, conchoidal fracture, and close granular texture. Its outcrop is marked by irregular blocks, which are very hard, and give a ringing sound when struck. Where it has been long exposed to atmospheric action, the decomposition of its constituent minerals causes it to be covered with an incrustation of a bright ferruginous yellow earth, which, mixed with the soil about the dykes, induces the ignorant and over-sanguine to conceive that they behold a bed of bog-iron ore.

This dyke is the same which crosses the Cumberland Valley, and cuts through the Blue Mountain 2 miles E. of Sterrett's Gap. It crosses Fishing Creek Valley and the Cove Mountain, bearing N. 10° E., where it forms a low ridge, separating the waters of Fishing Creek from those of Sherman's Creek.

The dyke next crosses the Cove, where its loose fragments are strewed over the surface to a great extent.

The point where the dyke cuts the Northern ridge of the Cove Mountain is not visible, but we find the mass three-fourths of a mile N. of Petersburg, whence, with a bearing N. 30° E., we trace it for many miles. It reaches the Juniata $1\frac{1}{4}$ miles above the head of Duncan's Island, where it can be seen well exposed on the Turnpike. From the Juniata it is traceable to the Susquehanna, where it appears immediately below Montgomery's Ferry. It cuts the Half-Fall Mountain a mile from its N.E. extremity.

Where the trap-rock comes in contact with red shale, the shale is indurated, and altered to a dark brown and purplish colour.

The surface of the dyke is from 60 to 120 feet wide, though the actual thickness of the intrusive wall of rock beneath the surface is probably much less.

From the Blue Mountain to the point where it reaches the Susquehanna its length is 15 miles, but it crosses the river and passes into Lykens Valley; its total extent is therefore considerably greater.

FIG. 74.—From Blacklog Mountain, S.W. of Meadow Gap, to Blue Mountain, 3 miles S.W. of Strasburg.

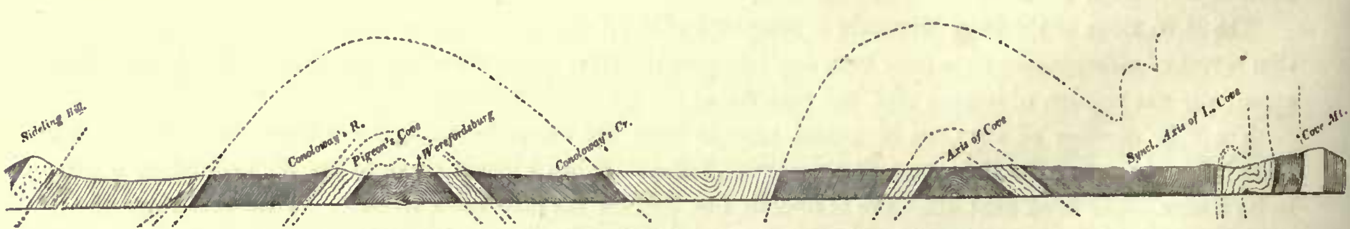

FIG. 75.—From Sideling Hill past Werefordsburg to Little Covo Mountain.

DIVISION II.

THIRD SYNCLINAL BELT, OR TUSCARORA VALLEY; AND THIRD ANTICLINAL BELT, OR SHADE AND BLACKLOG MOUNTAINS.

ANTICLINAL BELT.

GENERAL DESCRIPTION.

BETWEEN the extensive valley of Lewistown and its prolongation the Great Aughwick Valley on the N.W., and the general valley of Juniata County and the Townships of Huntingdon County on the S.E., there are several distinct mountains, composed of the Levant sandstones, lifted by three great anticlinal flexures. The most N.E. of these is the Eastern Shade Mountain, which originates in Union County, 8 miles W. of Selinsgrove, and extends S.W. to its termination in Mifflin County, S. of Lewistown. The next further to the S.E., which is like the preceding in its structure, originates in Juniata County N.W. of Mifflintown, and stretches S.W., terminating at Edward Furnace in Huntingdon County. It is called the Blue Ridge. Between it and the Shade Mountain there lies the narrow trough or defile termed the Long Narrows of the Juniata. To the S.E. of the Blue Ridge in Juniata County, 3 or 4 miles W. of Mifflintown, another anticlinal mountain rises, which to the S.W. separates into the two monoclinal mountains enclosing the slender valley of Blacklog. Of these the N.W. is the Blacklog Mountain, and the S.E. the Western Shade Mountain. Between the Blue Ridge and the Blacklog Mountain lies the narrow valley called Negro Valley, in Huntingdon County, and Licking Creek Valley in Juniata County.

There is some confusion in the use of the names applied to these mountains, the whole range, from Union to Fulton County, as seen from the S.E., being grouped under the general name of Shade Mountain.

In the following description the more Eastern will be treated first. But before entering upon details, it will be expedient for the reader to inspect the group of sections, indicating the structural features of both the anticlinal and synclinal belts.

CHAPTER I.

LEVANT SANDSTONES IN THE EASTERN SHADE MOUNTAINS AND BLUE RIDGE.

THE anticlinal axis of this mountain crosses the Susquehanna about a mile N.W. of Selinsgrove, and traverses Chestnut Ridge until it enters the mountain, through the centre of which it runs to the termination of the mountain S.E. of Lewistown. Beyond this point the anticlinal axis is prolonged many miles S.W. in the higher formations, as I shall illustrate in a future Chapter.

The general course of the mountain, from its origin 8 miles W. of Selinsgrove to its termination 1 mile S.E. of Lewistown, is about S. 60° W. It rises nearly opposite Middleburg, and continues straight for a few miles, when it curves Southward until opposite Beavertown. There it bends N. again to run more Westward, to the notch or gap 3½ miles from Adamsburg, beyond which point, for nearly 10 miles, it ranges about S. 70° W. Here, in consequence of the introduction of several new axes in the valley adjoining, it again changes its course to S. 60° W., but recurves a second time to the Westward before it terminates, influenced no doubt by the axis of the Blue Ridge of the Juniata. The N.W. flank exhibits the above changes of direction more conspicuously than the S.E. The mountain is about 32 miles in length. Its crest ascending gradually from its N.E. point, and extends for 12 miles with a broad, rounded, and unbroken summit. About 10 miles from its N.E. end, the Levant grey sandstone rises to the surface along the middle of the mountain, and its crest becomes triple, the three ridges extending to within 6 miles of Lewistown. The middle ridge is divided from the two exterior crests of Levant white sandstone, by an elevated valley of the softer Levant red sandstone.

West of Richfield its S.E. flank is gashed by five or six ravines, occurring at intervals of half a mile.

The S.E. crest of Shade Mountain is cut by ten gaps, all of which, with two or three exceptions, give passage to streams. All these gaps have the same aspect. They have distinct names. The most N.E. is the Long Creek Gap, nearly opposite to McAllisterstown. S.W. of it are five gaps, at intervals of from half a mile to one mile, separating the mountain into sections, which in the neighbourhood are called *round tops*, and each has a special name. The other four gaps are at wider distances; the chief of these are S.W. in the Long Narrows. The flank of Shade Mountain in the Long Narrows is grooved by a number of deep ravines. The middle ridge is composed of the red conglomerate and green sandstone, the Levant grey or lower sandstone overlying the axis. At several points, however, where it has been cut down by denudation opposite to gaps in the S.E. crest, the upper portion of the Matinal newer slates is exposed. This may be seen N.W. of the Lost Creek Gap.

The conglomerate of the *middle* ridge is sometimes sufficiently hard and compact to be used for millstones.

The S.E. crest of Shade Mountain is sharp. It is composed of the Levant white sandstone, dipping 60° S.E. In the Long Narrows the inclination is even greater than this. The white sandstone in the Long Narrows yields beautiful specimens of *Arthrophycus Harlani*.

LEVANT SANDSTONES IN THE BLUE RIDGE AND ITS ANTICLINAL AXIS.

Extending from a point 3 or 4 miles N.E. of Richfield, in Union County, and passing N.W. of that town, there is an anticlinal axis ranging S.W., about half a mile from the base of Shade Mountain. It traverses the centre of Slenderdale Ridge, on the N.W. side of Lost Creek Valley, and finally dies away at the Juniata River, about 2½ miles N.W. of Mifflintown. This axis lies chiefly in the Surgent slates and marls. It is noticed here because it might by some perhaps be considered as a N.E. extension of the axis of Blue Ridge, although it is not really in the same line, for the N.E. extremity of the Blue Ridge axis is half a mile N.W. of it, ending abruptly against the base of Shade Mountain in such a manner that the two axes overlap or pass each other about 2 miles. But that the same undulation may have produced them is not improbable, when we consider the abrupt manner in which the Blue Ridge axis ends to the N.E.

The anticlinal axis of Blue Ridge occupies a central position throughout the whole course of the mountain. When this terminates, it is prolonged through Germany Valley, and ends W. of Orbisonia, as I shall more fully

MILLIGAN'S COVE IN WIL

Lehman

Russell Smith

VALLEY OF JUNI

OUNTAIN, FROM DRY RIDGE.

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explain in a subsequent Chapter. This axis exhibits a very regular inflection, convex towards the N.W., changing its direction from S. 55° W. to S. 35° W.

The *Blue Ridge* originates in Juniata County, 3½ miles N.W. of Mifflintown, and extends S.W. for 27 miles, curving gently to the S., and terminating in Huntingdon County at *Bell's Furnace*. It rises very gradually, becoming wider and broader, until it reaches its maximum altitude 4½ miles from its origin, when it becomes cleft over the line of the axis, and stretches S.W., with a double crest and intervening valley, for 20 miles, when the crests reunite, and the mountain, with a broad rounded summit, gradually descends, and terminates in a point.

The *extremities* of the Blue Ridge and Shade Mountain pass each other, forming between them the synclinal trough of the Long Narrows, which is 6½ miles in length. It is a narrow defile, overhung by steep slopes, strewn with immense fields of loose rocks, and traversed in its centre by the Juniata River. The flank of Blue Ridge is gored by a number of deep ravines in the Long Narrows, resembling the opposite flank of Shade Mountain.

The S.E. crest of the Blue Ridge is unbroken throughout its entire length, and its S.E. slope has an even surface, descending into the slender valley called Licking Creek Valley towards the N.E., and Negro Valley towards the S.W.

The N.W. crest, which is rather more than half a mile from the other, is broken by a number of gaps, each distinguished by a special name. Through these, streams draining the high valley between the crests pass out and fall into the Juniata. The gaps are all alike ; their names and positions are represented on the map. The N.W. slope of Blue Ridge bounds the S.E. side of the valley of Lewistown to the S.W. of that town. The valley between the crests of Blue Ridge is elevated and barren ; it is scooped more deeply in the neighbourhood of the gaps. The Levant red sandstone saddles the axis, and near the gaps the red conglomerate of the Lower or Levant grey sandstone is sometimes exposed.

The Levant white sandstone, dipping in opposite directions, composes the two crests of Blue Ridge—dip, 60° N.W. and 45° S.E. Its characters are the same as in the more S.E. outcrops already described. The flanks of the ridge are covered with loose fragments.

A small point of the white sandstone exists on the E. side of the Juniata, below the Long Narrows, where it sinks under the overlying shales. The upper beds of the Levant white sandstone are also cut through by a small stream below Edward Furnace, where the Blue Ridge is attenuated, and about to terminate. The axis or arch is there beautifully exposed.

CHAPTER II.

BLACKLOG VALLEY AND ITS ANTICLINAL AXIS.

Blacklog is an anticlinal valley. It is traversed centrally by an axis which lifts the Matinal rocks to the surface, and it is bounded by sharp-crested mountains of the Levant sandstones.

It is remarkable for its narrowness and great length. From one extremity to the other the distance is 36 miles, whilst everywhere the mountain-slopes almost meet in the centre. Both extremities are closed by the union of its bounding mountains, and the only entrances into it are through gaps notched in these ridges. The valley makes a gentle curve, with convexity, to the N.W. The slopes of the mountains are quite gentle near the base, and grooved by ravines. Higher on their flanks we discern an indistinct terrace. Blacklog Valley is thinly peopled. It lies in Juniata and Huntingdon counties. The mountain bounding it on the N.W. is called the Blacklog, and that on the S.E. the Shade Mountain.

Anticlinal Axis.—The anticlinal flexure or line of elevation which traverses Blacklog Valley, is one of the longest in the State. We first observe it in the Cadent and Vergent rocks 6 or 7 miles E. of McAllisterstown in Juniata County. Pursued S.W., it passes a quarter of a mile S.W. of that town, and, ranging through Lost Creek Valley, it becomes the axis of *Lost Creek Ridge.* It crosses the Juniata River about a mile above Mifflintown, and is in the centre of the *Forge Ridge.* It enters the Shade Mountain, which rises to the S. of Licking Creek Valley, and where this divides into the two crests enclosing Blacklog Valley, the axis ranges through that valley, beyond the end of which it extends into Fulton County, as we shall hereafter describe. From its N.E. extremity to the S.W. end of Blacklog, the distance is about 60 miles; the total length of the flexure may be stated at about 70 miles. In this distance it changes its direction from about S. 60° W. to S. 30° W., an alteration from a straight course of 30°.

Auroral Limestone Blacklog Valley.—The Auroral magnesian limestone makes its appearance in this valley as a narrow zone about 9 miles long. It emerges from beneath the overlying slate 5 miles N.E. of the gap S. of Orbisonia. Extending S.W., it lies chiefly on the S.E. side of Blacklog Creek, forming an elevated tract of arable soil. It vanishes in a point 2 miles S.W. of Shade Gap. The belt is about one-third of a mile wide opposite the gap in Blacklog Mountain, where the whole valley is rather wider than at any other point. The limestone is in an anticlinal position, dipping 70° N.W. and 60° S.E. The upper beds, graduating into the Matinal slate, are dark-coloured and argillaceous, and without fossils. Below these are very massive strata of a pure blue limestone, alternating with a lighter-coloured magnesian rock, some beds of which are doubtless well suited for the making of hydraulic cement. Some of the lowest layers exposed are fossiliferous.

The formation exhibits no traces of iron ore in this valley.

Matinal Slates, Blacklog Valley.—The Matinal slates occupy the North-eastern part of Blacklog Valley exclusively for 18 or 19 miles. They reach about one-third of the height of the bounding mountain, forming gentle and arable slopes, which are cut by numerous ravines. In the extreme N.E. end of the valley the slate does not occupy the mountain-flanks, and where the limestone appears it ranges on each side of this, holding its usual position along the base of the mountain. It saddles the limestone, and usurps the whole S.W. extremity of the valley, terminating where the mountains unite S.W. of Pott's Gap. In the S.E. side of Blacklog Valley the dip is 50° S.E., and in the N.W. 65°. Its characters correspond to the description given of it for Path Valley.

Levant Sandstones in the Mountains bounding Blacklog Valley.—This group possesses its triple character in these mountains. The lower member, or Levant grey sandstone, forms the brow of a slight terrace; the middle, being softer, has been more affected by denudation; and the upper, or hard Levant white sandstone, forms the crests. Some of the beds in this latter mass are here, as in many parts of Huntingdon, Fulton, and Bedford counties, of a pinkish colour.

These Levant sandstones, as elevated by the axis of Blacklog Valley, first appear 3 miles S.W. of the Juniata River. The Levant white sandstone rises in a broad mountain with rounded summit, the crest ascending in a very gradual manner to its most elevated point 6 miles from its origin, when it divides into two ridges to enclose Blacklog Valley.

The *Blacklog Mountain* extends for 36 miles, terminating S.W. in a knob in Bedford County at Fort Littleton, by reuniting with the other monoclinal ridge, here called the Shade Mountain. It bounds, on the S.E., Licking Creek Valley in Juniata County, and Negro Valley in Huntingdon County. Further S.W. it separates Germany Valley and the valley of the Great Aughwick Creek from Blacklog Valley.

The *Blacklog Mountain* towards its S.E. extremity is cut by two gaps $1\frac{1}{4}$ miles apart, through which tributaries to Licking Creek pass from the head of Blacklog Valley. Rather more than 4 miles S.W. of these is a notch, the crest of the mountain between being nearly straight. Tracing the summit S.W. for 11 miles, it is unbroken, until we arrive at another notch or gap. Opposite Germany Valley, the bottom of the notch is about half the height of the mountain. From this notch S.W. the Blacklog curves slightly towards the W., and then again resumes its original direction ; its crest is straight or slightly indented as far as the gap S. of Orbisonia. This gap is a narrow defile giving passage to Blacklog Creek.

The *Meadow Gap* is an elevated notch $5\frac{1}{2}$ miles S.W. of Orbisonia, the mountain between having a narrow slightly-undulating crest ; 3 or 4 miles S.W. of the Meadow Gap a similar notch occurs in Fulton County, the mountain between being unbroken ; the S.W. end is an abrupt knob.

The N.W. slope of the Blacklog Mountain throughout its whole course is nearly regular. It is steeper near the crest and more gentle towards the base, and has been very slightly furrowed by denuding currents.

The S.E. flank is much more broken. In the N.E. extremity of Blacklog Valley, which is considerably elevated above the level of the surrounding country, the Levant grey sandstone does not rest on the flanks of the mountain, but forms two low ridges, with the axis between them, in the middle of the valley. These ridges are separated from the main crest of the Blacklog and Shade mountains by narrow valleys or hollows, which to the S.W. gradually becoming effaced, and the ridges ascending higher on each mountain, terraces are formed by them.

The terrace on the S.E. flank of the Blacklog Mountain is two-thirds of its height ; it is very narrow, and cut by numerous gorges. These are at wider intervals towards the N.E., being distant from each other from half a mile to one mile, but to the S.W. they are more frequent, and the terrace is merely a chain of protuberances or knobs.

The terrace is by no means so distinct in this mountain as in those encircling Kishacoquillas Valley, although the same rocks form it. The stratum supporting the terrace is the Levant grey sandstone, chiefly a massive red conglomerate and greenish coarse sandstone.

The rocks throughout Blacklog Mountain dip 70° N.W.

Iron Ore in Blacklog Mountain.—A deposit of iron ore exists on the very summit of Blacklog Mountain, 4 miles S.W. of Orbisonia. It was first opened by Mr J. Bell, and is now no longer mined. The ore and clay in which it lies seem to fill a transverse fissure or cleft in the Levant white sandstone, at a point where there is a slight indentation in the crest of the mountain. It is a dark reddish brown variety of the hydrated oxide of iron, rather cellular and very ponderous, and abounds in masses, having the cylindrical or stalactitic structure—pipe ore. It was smelted at Rockhill Furnace, and produced a good iron, somewhat " Red Short." The quantity of ore is necessarily circumscribed, owing to the peculiar conditions under which it is found.

It is probable that a similar fissure, with ore in it, exists in the neighbourhood of the Meadow Gap, as fragments of ore have been observed on the surface there in a line crossing the mountains.

Levant Sandstones—Shade Mountain, S.E. of Blacklog Valley.—This ridge separates Blacklog from Tuscarora and the Little Aughwick valleys. From its point of divergence from Blacklog Mountain to Cook's Gap, a distance of 5 miles, it is unbroken. It exhibits an irregular flexure bending towards the S., and then taking its original course. This bend, which is very distinct, is attributable to the influence of an anticlinal axis extending close along its S.E. base ; the Blacklog Valley expands S.W. of this curve.

In *Cook's Gap* the upper or Levant white sandstone only is cut through, whilst the lower or Levant grey sandstone still remains as a continuous barrier about half of the height of the mountain. Deep hollows exist on each side, especially on that of the terrace.

From Cook's Gap south-west to Shade Gap, a distance of $22\frac{1}{2}$ miles, the Shade Mountain is exceedingly uniform. Its summit is nearly level, and it curves gently Southward, preserving a parallelism with Blacklog Mountain.

Shade Gap gives passage to a branch of the Blacklog Creek.

The Shade Mountain, S.W. of Shade Gap, has a number of deep indentations, giving its summit a curiously undulated appearance.

Pott's Gap is 6 miles S.W. of Shade Gap, and $2\frac{1}{2}$ miles from the extremity of the mountain, and is a wide breach. From Pott's Gap south-west the flank of the mountain is grooved by deep ravines. Shade Mountain ends by meeting Blacklog Mountain in a high knob N.E. of Littleton in Bedford County. The Surgent iron sandstone forms a considerable hill appended to its extremity.

The S.E. slope of Shade Mountain has an even surface, broken only by the gaps which have been mentioned.

The Levant grey sandstone forms a low ridge a mile or two in length in the N.E. end of Blacklog Valley. This, ascending on the flank of Shade Mountain, produces a terrace which, N.E. of Cook's Gap, is several hundred yards wide. S.W. of this last-named gap, the terrace becomes quite indistinct, and indeed is merely represented throughout the whole course of the mountain by a chain of protuberances or knolls, separated by shallow ravines. In summer the ravines support a light green vegetation, and the knolls wear a darker hue from being covered with pines. Opposite the indentations in the summit of the mountain S.W. of Shade Gap, wider and deeper ravines separate these knolls.

The Levant sandstones in Shade Mountain dip 60° S.E.

CHAPTER III.

THIRD, OR TUSCARORA VALLEY SYNCLINAL, AND ITS SEVERAL BELTS OF THE LOWER AND MIDDLE LEVANT ROCKS.

THE Southern portion of Union County, the entire area of Juniata County, and Dublin and Tell townships of Huntingdon County, occupy an irregular valley lying between the Shade Mountains on the N.W., and the Tuscarora Mountains on the S.E., and extending from the Susquehanna River south-west for about 70 miles. This valley, which is much subdivided, presents geological features which bear some analogy to those of the valley S.E. of Jack's Mountain. Thus, next its two extremities it has the structure of a great synclinal basin containing the Vergent and Ponent formations, which impart a barren soil, whilst in the intermediate space the Surgent and Pre-meridian strata are brought to the surface by anticlinal axes, and form highly fertile belts.

On the Susquehanna River the formations which occupy the belt of country before us take their dips from the extensive axes of elevation prolonged from the anthracite coal region. On the N.W. an anticlinal axis crossing the river passes a mile N.W. of Selinsgrove, and extends S.W. as the axis of the N.E. Shade Mountain ; and 11 miles below Selinsgrove, at the mouth of the West Mahantango Creek, another anticlinal axis, coming from the N.E., crosses the Susquehanna, but dies away after a course of a few miles. About 2 miles more to the S.E. another anticlinal flexure, originating E. of the river, ranges through the centre of Pfout's Valley and the crest of Tuscarora Mountain.

Between the anticlinal axes of the Shade and Tuscarora mountains in the S. portion of Union County and the N.E. part of Juniata County, the whole tract is a simple basin of the Cadent, Vergent, and Ponent rocks. To the S.W. in Juniata County this simplicity disappears ; four nearly equidistant anticlinal axes originate between the Tuscarora and Shade mountains, and extend S.W. for many miles.

The *First Axis* originates 4 or 5 miles N.E. of Richfield, in the Cadent slates, three-fourths of a mile S.E. of the base of Shade Mountain, parallel to which it extends S.W. It passes within a few hundred yards of Richfield, ranging in a straight line to the end of Slenderdale Ridge, 4 miles further. It traverses the Slenderdale Ridge centrally, and finally dies away at the Juniata River, nearly one-half of a mile S.E. of the axis of Blue

Ridge, overlapping it for the distance of 2 miles. This axis, which we may call the *Slenderdale Ridge Axis,* is 23 miles long, and nearly straight.

The *Second Axis* to the S.E. is that of *Blacklog Valley.* It is about $1\frac{3}{4}$ miles from the preceding, and parallel to it. It has been already traced from M^cAllister's to Lost Creek Ridge, in connection with the description of Blacklog Valley.

The *Third Axis* of the Valley of Juniata County is $2\frac{1}{4}$ miles S.W. of the *Blacklog Valley* axis, and parallel to it. Its extremity is in the Cadent and Vergent rocks, 3 or 4 miles N. of the East end of Tuscarora Mountain. Pursued S.W., it runs 2 miles N.W. of Thomastown, and occupies the middle of the little valley of Surgent marls, called Kurtz's Valley. It extends to the Juniata, passing $1\frac{1}{4}$ miles N.W. of Mexico, and about the same distance from *Mifflintown.* From the river, for 12 miles S.W., it occupies the centre of the broken ridge, which separates the two N.E. divisions of Tuscarora Valley, and dies away near the base of Shade Mountain, 2 or 3 miles S.W. of Cook's Gap. This axis, which may be designated as the *Kurtz Valley Axis,* is 30 miles long, making a gentle and regular flexure to the Southward.

The *Fourth Axis,* or most S.E. anticlinal of the Valley of Juniata County, arises in the Surgent marls, a little S. of Thompsontown, whence it extends S.W., ranging three-fourths of a mile distant from the base of Tuscarora Mountain. It crosses the Juniata three-fourths of a mile S.E. of Mexico, and extends thence S.W. through the S.E. division of Tuscarora Valley, midway between the mountain and the limestone ridge, and passes one-third of a mile N.W. of Beale's Mill, and finally dies away in the Cadent and Vergent rocks, a short distance E. of Waterford. This axis is 22 miles long, and lifts Surgent marls with their red shale throughout the greater part of its range. At its origin it is about 2 miles S.E. of the preceding, and diverges from it as it is traced S.W.

Besides the four axes thus noticed, the anticlinal Tuscarora Mountain terminates several miles E. of Waterford. Its axis is prolonged for some miles further S.W., along the S.E. border of Tuscarora Valley ; but this will be described more particularly in another place.

GENERAL CHARACTERS OF THE SURGENT MIDDLE AND LOWER GROUPS.

These rocks, which I shall describe together, undergo throughout the whole district now under consideration but little change, a fact in accordance with the general law, that however rapidly some of our strata alter in thickness and aspect in their spread toward the N.W., they are singularly persistent in these respects in their extension in the longitudinal direction, or N.E. and S.W.

An inspection of the vertical column of Surgent strata for the locality of Mifflintown will convey to the reader a correct conception of the average composition and relative development of the several members of the series in this district. Each formation fluctuates a little in its thickness, and all of them, if we except the Surgent iron sandstone, augment in size as they cross this comparatively narrow valley toward the N.W. The strata which exercise the greatest influence upon the topography are the two sandstones of the slate and shale groups, the interval between which varies from about 200 to 300 feet.

The *Surgent iron sandstone* is only a few feet in thickness, and therefore produces a less marked effect upon the surface than in Perry County, where it is so much more massive.

The *Surgent ore sandstone* is from 20 to 30 feet in thickness, and is composed of beds of various hues and composition.

Surgent Slates, Ore Shales and Marls.—These rocks are widely distributed in Juniata County, and that portion of Huntingdon which is its natural continuation S.W. They form two great zones, one on each side, at the base of the bounding mountain. But they spread out to a much greater extent in the central part of Juniata County.

We shall first trace the N.W. belt, proceeding from N.E. to S.W.

Some beds of the ore sandstone are white, hard, and fine-grained ; the prevailing colour is light brown and ferruginous. Other layers are manifestly calcareous, but near the outcrop the lime has been dissolved, and a soft ferruginous sandstone remains. The calcareous strata are fossiliferous.

This sandstone, from its hardness, wherever it is uplifted to the surface, forms, unless high on the flank of a mountain, quite a distinct ridge. It composes the ragged ridges which are appended to the extremities of all the anticlinal mountains of the Levant white sandstone in the district, and frequently produces protuberances along their flanks.

Fossiliferous Iron Ore.—This ore is associated with the sandstone just described, forming its upper layer, as in some localities in Mifflin County.

After having seen this ore at many different points in Juniata County, and in the lower end of Huntingdon County, we think it may be fairly concluded that its value is trivial. At one point only was it found to be of pure composition, and there its thickness is inconsiderable. Its prevailing character is that of a calcareous sandstone, very highly impregnated with the peroxide of iron. It is perhaps sufficiently rich in iron at some points to constitute an ore, but the quantity of silicious matter is evidently such as to impair its value. It is brought to the surface abundantly by the several axes of elevation. The ore is scarcely to be found along the N.W. base of the Tuscarora Mountain. The particular localities visited will be noticed in connection with the description of the range of the formation.

Above the ore are a few beds of fossiliferous limestone alternating with shale.

Surgent Ore Shales and Marls, S.E. Base of Shade Mountain E. of the Juniata.—The exact point where the upper beds of the Surgent marl group appear along the Shade Mountain axis is N.W. of Selinsgrove in Union County. Crossing Middle Creek, $2\frac{1}{2}$ miles S.W. of Selinsgrove, the group saddles the anticlinal axis of the mountain, the South-east-dipping strata inclining at an angle of 25°, and those on the N.W. at an angle considerably steeper.

Immediately S.W. of Middle Creek, a low, broad, and broken ridge rises and extends S.W. to the end of Shade Mountain, a distance of 6 miles, where it separates into two smaller monoclinal divisions, which enclose the N.E. extremity of Shade Mountain, and are prolonged some distance, until they become lost along the base of the mountain. This long hill receives the name of Chestnut Ridge. Its structure is evident from its features. It is formed by the Surgent iron and ore sandstones on the axis of the Shade Mountain. The sandstones rest on either flank, and the inferior slates occupy the middle. Seen from a height, this ridge has a triple contour, the sandstones forming the two outer crests, and the older slate folding over the axis, the inner one. The S.E. dips are gentle. As the Shade Mountain rises, the S.E. prong of Chestnut Ridge extends along its base, becoming lower and more broken, until it finally disappears opposite Richfield, the strata in it becoming levelled. No *fossiliferous ore* has been detected on Chestnut Ridge, or its continuation, as far as Richfield, although search was made for it in its usual position. The ore sandstone of the ridge corresponds to the general characters already attributed to it. The Surgent older slate on the summit of the ridge forms a thin soil, which is partially cultivated. Further to the South-westward this slate, along the slope of the mountain, is covered by debris.

The red shales and marls S.E. of Chestnut Ridge and the Shade Mountain, form, as far as Richfield, the N.W. side of a fertile little valley, which is bounded on the S.E. by a low ridge of the Pre-meridian limestone and Meridian sandstone, called Flintstone Ridge. This valley is perhaps about half a mile wide throughout, extending from Middle Creek for 12 miles to the S.W. It is called in the neighbourhood Klopperdale to the N.E., and Heister's Valley to the S.W., although it is strictly continuous. The red shale dips 30° S.E., and forms a level surface.

Surgent Rocks.—Axis of Slenderdale Ridge.—A mile N.E. of the town of Richfield, the anticlinal axis which, traced S.W., is that of Slenderdale Ridge, lifts from beneath the overlying formations a narrow belt of the Surgent marls. This passes immediately N.W. of that town, the strata dipping 60° N.W., and 30° S.E. A short distance W. of Richfield, the belt coalesces with the South-east-dipping strata, nearer to the base of the mountain, by the termination of a synclinal tongue of Scalent limestone between them, and from that point S.W., for the distance of 8 or 9 miles, the Surgent marls and slates extend with three dips. Near Richfield these rocks form the N.W., and much the largest portion, of a small valley between the mountain and Flintstone Ridge. This valley, which receives no particular name, is subdivided to the S.W. by the emerging of the Surgent ore sandstone along the axis constituting Slenderdale Ridge. The space between the ridge and the mountain is here called Slenderdale, and extends nearly to the Juniata, whilst that on the S.E. opens into Lost Creek Valley, at McAllisterstown, or may be considered rather as an extension of it.

The zone of Surgent rocks thus noted with three dips is more than a mile wide. Its S.W. limit is rather high on the flank of Shade Mountain, and its S.E. edge a few hundred yards from the base of Flintstone Ridge. The lower beds crop out on the mountain with a S.E. dip, the sandstone belt not there affecting the surface. The red shales form a good soil, which is, however, much covered with debris towards the base of the mountain.

South of McAllisterstown, the Surgent marls emerge from the overlying sandstones in two anticlinal tongues, which quickly unite. The more N.W. of these contains the anticlinal axis which, prolonged S.W., is that of Blacklog Valley. The other is a short axis, soon effaced, to the S.W., in the red shales. The belt of Surgent strata, thus lifted, unites with the zone previously described, round a synclinal point of limestone, half a mile S.W. of McAllisterstown, and extends on in an undivided zone to the Juniata, traversed by two anticlinal axes, and forming by far the largest portion of Lost Creek Valley. Its S.W. limit is high on the flank of Shade Mountain, and its S.E. reaches the Juniata at Mifflintown. It is 3½ miles wide, and between 8 and 9 long. Its surface is broken by two ridges, formed of the sandstone, heaved up along the two anticlinal axes. The most North-western of these is

Slenderdale Ridge.—This ridge stretches with regularity from its origin, 4 miles N.E. of McAllisterstown, to the Juniata, below the Long Narrows, a distance of 14 miles. It is low and broad, embracing between it and Shade Mountain a very narrow valley called Slenderdale. It bounds Lost Creek Valley on the N.W., and is broken in several places to give passage to the streams descending from the gaps of Shade Mountain.

It is nearly half a mile wide through its base. The Surgent ore sandstone rests on its flanks. The Surgent older slate on the crest is in many places cultivated, but affords a rather poor soil. Both the iron and ore sandstones exist in Slenderdale Ridge, along a double line of outcrop. They dip 20° S.E. and 70° N.W.

Fossiliferous Ore (Slenderdale Ridge).—This has been discovered at one point on Slenderdale Ridge, on the farm of Mr Haughawout, N.W. of McAllisterstown. It is there a stratum about 6 inches thick, is pure, and has the usual aspect. It lies *under* some heavy beds of greyish-brown sandstone—the true ore sandstone. It is on the N.W. flank of the ridge, and dips 70° N.W. This is the only locality in Juniata County where the fossiliferous ore was found pure; and as its position with respect to the sandstone is unusual, it is evidently a distinct stratum from the abundant impurer variety.

This ore has obviously a restricted range, though it has been found on the surface at other points in the same neighbourhood. The thinness of the stratum, and its position beneath a hard sandstone, make it of little value. At the S.W. end of Slenderdale Ridge, where it flattens down, the sandstone is seen on the turnpike thrown into several contortions, and fragments of the silicious ore are to be found on the surface. As we before mentioned, the anticlinal axis of Slenderdale Ridge flattens down immediately S.W. of the river.

Slenderdale.—This narrow valley is a synclinal trough of the Surgent marls and red shales. Where these appear the soil is good, but the surface is to a great extent covered with debris from the mountain. It is partially cultivated.

N.W. of Slenderdale the lower member of the Surgent slates crops out one-third of the distance up the slope of the Shade Mountain, dipping 60° S.E. The sandstone does not affect the evenness of the slope, and no ore was observed associated with it.

In the S.W. end of Slenderdale the axis of Blue Bidge originates close to the base of Shade Mountain, 1½ miles or more N.E. of the Juniata. Where it first appears the red shales lap over it, but as it is traced S.W., lower strata successively emerge until the ore sandstone reaches the surface; and as it folds over the axis, it forms a little crescent-shaped ridge enclosing a hollow scooped out of the Surgent lower slate. Where the axis reaches the river the Levant white sandstone emerges, detaching on the N.W. a synclinal zone of the lower slate which enters the Long Narrows.

Long Narrows.—This defile is 6½ miles long; the mountains on each side approach very closely, confining a narrow belt of Surgent lower slate, over which the Juniata river flows. The strata on the N.W. side dip 50° S.E., and those on the other are still steeper. There is little probability that the ore sandstone and the fossiliferous ore exist in the Long Narrows: if they do, their position is in the bed of the river. Along the turnpike, frequent exposures of the Surgent lower slate, and of the upper or fucoidal beds of the Levant white sandstone, are to be seen. These are in some places partially overturned, so as to dip to the N.W., appearing to be displaced by the pressure of the steep hill-side.

The Surgent slate in the Long Narrows does not extend high upon the mountain-flanks; followed S.W., it unites with the same formation of the N.W. side of the Shade Mountain, by folding over its anticlinal axis S.E. of Lewistown.

Surgent Slates and Shales in Lost Creek Valley.—This valley is vaguely defined. It is bounded on the N.W. by Slenderdale Ridge, and on the S.E. by Lost Creek Ridge, consisting of the Meridian sandstone. It is more than 2 miles wide and 9 or 10 long, is drained by Lost Creek—whence its name—and is a fertile and well-cultivated district, underlaid chiefly by the Surgent slates and marls, and composes the S.E. portion of the broad zone which we have described as extending from near McAllisterstown to the Juniata River above Mifflintown.

To within 4 miles of the Juniata this valley contains simply the Surgent marls traversed by the anticlinal axis of Blacklog Valley, but from that point S.W. it is separated into two divisions by the intrusion of a low broad ridge composed of the ore sandstone lifted by the same axis, and extending to the Juniata. It is called

Lost Creek Ridge.—There are two ridges which receive this name. The most South-eastern, composed of the Pre-meridian limestone and Meridian sandstone, bounds Lost Creek Valley, until it terminates at Cedar Spring, whilst the other ranges through the S.W. portion of the valley, separating it into two divisions. This last is 4 miles long, and has a flat summit and a regular contour, and, as already mentioned, is anticlinal with the Surgent ore sandstone belts resting on each flank, and folded over its N.E. extremity. Its S.E. strata dip 20° S.E., while those on the N.W. side are nearly perpendicular. The Surgent older slate overspreads the summit.

No fossiliferous ore was discovered on the N.W. Lost Creek Ridge, although on a ridge on the opposite or S.W. side of the river, which is a continuation of it, ore has been found. The proper position for the ore is immediately on the upper layer of sandstone; it will probably be found to be of little value, on account of its silicious composition. Between Lost Creek Ridge and the S.E. limit of the Surgent marls which passes through Mifflintown, the red shale and other strata have a gentle S.E. dip. Between the N.W. Lost Creek Ridge and Slenderdale Ridge the red shales and marls form a synclinal trough, the same which embraces the Scalent limestone at McAllisterstown, and in which, near the Juniata River, the same limestone appears in connection with the dying away of the Slenderdale Ridge anticlinal axis. These Surgent marls have a gentle S.E. dip and a steep N.W. dip, and form an undulating surface of the usual pleasing aspect.

Surgent Slates and Shales S.W. of the Juniata, above Mifflintown.—A little to the S.E. of the point where the axis of Slenderdale Ridge dies away at the Juniata, the synclinal axis in which it flattens down receives the Pre-meridian limestone. This basin is formed of strata, dipping towards a central line from the Blue Ridge and Blacklog axes, and prolonged S.W., is the synclinal trough of Licking Creek Valley. There are here two zones of the Surgent slates and marls, one on each side of the limestone. That on the N.W. is monoclinal, and lies at the base of the Blue Ridge, extending from the Juniata 5 miles S.W., where it coalesces with the belt on the S.E. in Licking Creek Valley by the ending of the limestone. Its strata incline 30° S.E. Near the Juniata the ore sandstone forms a distinct ridge, which, in the course of a mile or two, becomes lost on the slope of Blue Ridge, upon which some excavations have been made in the fossiliferous ore.

Hardy's Ore Bank.—This ore is of little value, from its containing a large portion of arenaceous and other foreign matter. It is ponderous, of a red colour, and has grains of sand dispersed through it. It is 18 inches or 2 feet thick, and dips 30° S.E. It was tested in the Montebello Furnace, and found to be of inferior quality. It no doubt continues for some miles S.W. of the river. Its position is just above the highest layer of the Surgent ore sandstone.

The red shale and marls of the belt under consideration lie along the base of the Blue Ridge, one-fourth of a mile S.E. of which runs their boundary.

From the Juniata River S.W. to the extremity of the mountain which encloses Blacklog Valley, extends Forge Ridge, which is properly a continuation of the Lost Creek Ridge.

Forge Ridge.—This ridge extends centrally in an anticlinal belt, limited on the N.W. by the synclinal tract of limestone which passes into Licking Creek Valley, and on the S.E. by a similar tract of limestone which stretches through the N.W. division of Tuscarora Valley, from a point opposite Mifflintown. The zone of Surgent slates and marls thus constituted is nearly 2 miles wide, and extends for 3 miles S.W. from the river, when it separates by the emerging of the Levant white sandstone along the line of elevation. The division on the N.W. side of the axis enters Licking Creek Valley, and becomes united along the synclinal line with the South-east-dipping strata, which lie at the base of the Blue Ridge. That on the S.E. lies at the base of the Shade Mountain, along the N.W. border of Tuscarora Valley. The Forge Ridge is 3 miles long. It is low and broad, being nearly three-fourths of a mile wide through the base. Its outline is ragged, and it is cut near the middle to give passage to Licking Creek. It terminates to the N.W. by splitting and enclosing the N.E. extremity of the mountain formed by the union of Blacklog and Shade Mountains, along which one spur or crest extends on each side for nearly 2 miles, until it grows indistinct on the mountain-slope.

The Surgent older slate, iron sandstone, and newer slate, compose the summit of the Forge Ridge, folding over the axis, and the ore sandstone rests on its flanks. This sandstone is about 20 feet thick, and corresponds to the description which has been already given. It is well exposed on the river W. of Mifflintown, at Jacobs's Ore Bank. The rocks in the Forge Ridge have the N.W. dip much steeper than the S.E., the whole of the Blacklog flexure being a fine instance of a normal axis.

Fossiliferous Iron Ore.—An ore occurs in the Forge Ridge, which holds the position, and is no doubt the equivalent, of the fossiliferous ore, although its characters are somewhat different. It occurs in a bed from 18 inches to 2 feet thick, resting on the upper layer of the ore sandstone; it is ponderous, and cleaves rectangularly, is of a red colour, and contains numerous fossils. It is, however, very silicious. This can be well seen on the planes of the joints, where the crystalline grains of silex are very evident.

Jacobs's Ore Bank.—A considerable quantity of this ore has been quarried on the river-bank W. of Mifflintown. It belongs to the South-east-dipping strata of the Forge Ridge. Its value is rather inferior.

The same variety of ore was discovered at various points along the Forge Ridge, and specimens collected. It can easily be detected by its relation to the underlying sandstone, and must exist on both flanks of the ridge.

The marls and their red shale along the N.W. base of the Forge Ridge form a well-cultivated surface a quarter of a mile wide, extending into Licking Creek Valley, and bordering its S.E. side.

Licking Creek Valley.—This is a narrow synclinal valley formed between the Blue Ridge on the N.W., and the Blacklog Mountain on the S.E. It is wider towards the N.E., but, traced S.W., the mountain-slopes meet in the centre. It is 26 miles long, ending at Bell's Furnace, in Huntingdon County, where it receives the name of Negro Valley, although the two are strictly continuous. Licking Creek Valley makes a gentle curve S., changing its bearing from S. 60° to S. 35° W. It is drained by a stream of the same name, and is almost uninhabited.

The synclinal axis of Licking Creek Valley embraces, as already noticed, in its N.E. extremity, a narrow tongue of limestone. This terminates about 5 miles S.W. of the Juniata, and from that point S.W. the Surgent marls or shales, and then the slates, occupy the valley, the latter ascending on the mountain-flanks about one-third of their height.

The ore sandstone, with the associated ore, traverses the valley in two lines of outcrop. At no point was the fossiliferous ore detected in Licking Creek, minute investigations being forbidden by the nature of the surface.

Judging from the quality of the ore at both extremities, we cannot impute to it much value. Tracing the Levant and Surgent rocks from Negro Valley, the South-east-dipping strata saddle the anticlinal axis of Blue Ridge, and pass into Germany Valley, those on the S.E. ranging along Blacklog Mountain, as will be shown hereafter. The surface of the formation is much covered by loose materials.

Surgent Slates and Shales S.E. of the Forge Ridge.—The marls lying along the S.E. base of the Forge Ridge border the N.W. division of Tuscarora Valley. They dip 20° S.E. When the Levant white sandstone of the mountain appears, the whole belt of the slates and marls branches into two, the tracts on the S.E. occupying the S.E. flank and base of the mountain, having its S.E. limit at the narrow limestone tract which occupies the middle of the N.W. division of Tuscarora Valley. This zone shows a uniform dip to the S.E. About 8 miles S.W. of the Juniata at Mifflintown it coalesces with a corresponding belt, elevated by the Kurtz Valley anticlinal axis.

Surgent Slates and Shales—Kurtz Valley Anticlinal Axis.—A mile and a half S.W. of Thomastown is the extremity of a little valley, which to the S.W. unites with Lost Creek Valley. It is called Kurtz's Valley. The old road from Mifflintown to Thomastown passes through it. It is closed up to the N.E., but becomes wider in the opposite direction, and is bounded on both sides by low ridges of Meridian sandstone and Cadent and Vergent rocks. It is nearly a mile wide, and between 5 and 6 miles long. The ridges separating it from Lost Creek Valley terminate at Cedar Spring, 2½ miles N.E. of Mifflintown. The name given to it is applied more particularly to the N.E. portion, that to the S.E. being included in the valley of Lost Creek.

The turnpike road from Thompsontown to Mifflintown is parallel to Kurtz's Valley, and separated from it by a mass of ridges of the Meridian sandstone and Cadent and Vergent strata one mile or more wide.

The Surgent and Scalent marls elevated by a broad anticlinal axis, the range of which has been traced, emerge from the overlying limestones in the N.E. end of Kurtz's Valley, where the road from Thomastown to McAllisterstown crosses it. The marls alone occur in the middle of the valley, their limit being a few hundred yards from the base of the bounding ridges on either side. The dip is about 30° on each side, and the surface is nearly level, with the exception of a few hills of red shale supporting a growth of cedar. From the mouth of Kurtz's Valley to the Juniata, the zone becomes gradually wider, lower strata emerging in succession until the ore sandstone appears. The N.W. limit of the marls passes a few hundred yards S.E. of Cedar Spring, and reaches the Juniata a little below Mifflintown. The limit on the S.E. passes about three-fourths of a mile N.W. of Mexico, and reaches the Juniata above the Perrysville Bridge. The turnpike from Mifflintown to Mexico crosses this belt, which is there nearly 1½ miles wide. The belt of ore sandstone forms elevated ground, which terminates abruptly at the river, where that member of the formation may be seen well exposed near the lock. No ore was found associated with it, although it probably exists, and is similar in character and situation to that in the Forge Ridge. The tract thus traced from Kurtz's Valley to the Juniata has a well-cultivated surface, which is at some points well covered with transported materials of the immediately contiguous strata.

Surgent Slates and Marls—Kurtz Valley Axis S.W. of the Juniata.—Following the same line of elevation S.W. of the Juniata, it is seen to expand and rise into a broad tract of the two Surgent groups, the ore sandstone in the centre forming a remarkable ridge, which extends 14 miles S.W. of the river, and separates Tuscarora Valley into its two N.W. divisions. It may here be proper to give a brief topographical sketch of this valley, and of its general structure.

TUSCARORA VALLEY.

This valley is bounded on the N.W. by the Shade Mountain and the Forge Ridge, the latter extending to the Juniata in a line with that mountain. On the S.E. it is bounded by two distinct mountains, which are usually confounded under the single name of the *Tuscarora Mountain.* The most North-eastern of these is anticlinal; it terminates 3 miles N.E. of Waterford, waning to a point, and saddled by higher formations. It bounds the Tuscarora Valley for 14 miles. S.E. of its extremity, and three-fourths of a mile distant, lies another mountain, and the two enclose Liberty Valley. The second mountain is monoclinal; stretching S.W., it separates the Tuscarora and Little Aughwick valleys from North Horse and Path valleys. *Tuscarora Valley* forms a large portion of Juniata County and Tell Township of Huntingdon County. It has an average width of 5 miles, and extends for 30 miles or more S.W. from the Juniata below Mifflintown. It has no natural separation from the valley of the Little Aughwick Creek, the two being strictly continuous.

The surface of Tuscarora Valley is much diversified, and portions of it are highly fertile. This is more especially the case near the Juniata, where the Surgent and Scalent marls and Pre-meridian limestone predominate.

The *N.E. portion* is separated by ridges into three well-marked divisions. Of these the more North-western is included between the Forge Ridge and Shade Mountain, and the ridge formed by the ore sandstone thrown up along the Kurtz Valley anticlinal axis. It opens upon the Juniata opposite Mifflintown, from whence it extends 12 or 13 miles S.W., becoming effaced as the S.E. bounding ridge dies away. It is more than half a mile wide, becoming contracted towards the S.W. It is synclinal, and contains the Surgent slates and Scalent marls, and a belt of the Scalent limestone, and is consequently very fertile.

The *Middle Division of Tuscarora Valley* extends from the Juniata above Perrysville. It is bounded on the N.W. by the anticlinal ridge of the ore sandstone, and when this terminates, it reaches the base of Shade Mountain at Cook's Gap. It is bounded on the S.E. by broken ridges of the Pre-meridian, Meridian, Cadent, and Vergent rocks, is nearly half a mile wide, and extends between 16 and 17 miles S.W., becoming continuous with the slender valley which lies close along the base of Shade Mountain.

The middle division of Tuscarora Valley is monoclinal, and is formed of the Surgent shales and Scalent marls and limestone, and is highly fertile. The Tuscarora Creek flows in it below Patterson's Mill. It is a mile or more from the North-western division.

The *S.E. Division* lies along the base of the Tuscarora Mountain, and is bounded on the N.W. by the *Lewistown Ridge.* It opens on the Juniata below Mexico. It is more than a mile wide, and becomes continuous with the S.E. portion of the Tuscarora Valley, in which Waterford and Waterloo are situated, contracting in width towards the S.W. The S.E. division is underlaid by the upper Levant group, including the sandstone, and, where not covered by debris from the mountain, is highly productive.

The middle and S.E. divisions of Tuscarora Valley are separated by a mass of ridges, consisting of the Pre-meridian, Meridian, Cadent, and Vergent rocks occupying a synclinal axis. Towards the S.W. these are close to the bounding mountains, with a wide district of sterile ridges between.

The S.W. part of Tuscarora Valley is chiefly occupied by irregular hills of the Cadent rocks, bordered by more fertile strips along the base of the mountains.

Ridge between the Middle and N.W. Division of Tuscarora Valley.—The ore sandstone in this ridge consists of layers of a white, grey, and brown colour, often irregularly stained. It has been used in constructing the piers of the bridges in the neighbourhood. The Ridge has no name. It stretches from the Juniata above Perrysville 14 miles S.W., approaching the base of Shade Mountain, and ending opposite Cook's Gap. It is low and broad, being perhaps a mile wide through the base at the widest point, and is notched to give passage to Licking Creek, and also at two other points where smaller streams cross it. Its summit is very much undulated, and has, when seen from a height, a distinctly triple outline. The sandstone, as it crops out on each side, forms a narrow broken crest, and the central part, composed of the Surgent older slates overlying the axis, is broad and rounded. The ridge has a gentle curve, and, contracting and ending close to the base of the Shade Mountain, the N.W. and middle divisions of the valley merge together. The central part of the ridge is in many places cultivated, though it affords but a thin soil.

Fossiliferous Iron Ore.—Some search has been made near Stuart's Mill on Licking Creek for iron ore. That which has been found is even more silicious than the ore of Forge Ridge. It holds precisely the same situation immediately over the upper bed of the ore sandstone, and is only a highly-ferruginous sandstone. Did any valuable ore exist in this ridge, it would be favourably situated for mining, for the dips are uniformly gentle ; but we are convinced, from observations made at various points, that none pure enough for use occurs.

The red shale and marls, with a N.W. dip, border the N.W. division of Tuscarora Valley, forming, with the strata dipping in an opposite direction, a synclinal trough, which embraces the Scalent limestone formation for a distance of 7 or 8 miles from the Juniata. Further S.W. they occupy it exclusively.

The same group S.E. of the ridge, of ore sandstone, borders the middle division of Tuscarora on the N.W.

Its S.E. limit passes N. of Perryville, Patterson's Mill, and McCoystown. These marls are inclined gently S.E., disappearing under the overlying limestone.

The Sandstone Ridge terminates opposite Cook's Gap in Shade Mountain, but its axis extends a mile or two further in the slates, and then flattens down, and the strata assume a uniform S.E. dip, occupying the base and flank of the mountain.

Surgent Slates and Scalent Marls S.E. of Shade Mountain.—From the point where the Kurtz Valley axis flattens down, S.W. of Cook's Gap, to the united extremities of Blacklog and Shade mountains, near Fort Littleton, these two groups extend along the flank of Shade Mountain with great uniformity for a distance of about 28 miles. The zone conforms to the flexures of the mountain, and preserves the same relations throughout. Its N.W. limit is one-third of the height of the mountain, its other margin being at the base, or a short distance S.E. of it. It is perhaps a quarter of a mile wide. The strata dip from 40° S.E. to 60° S.E. The surface, along the whole extent, is covered with transported rocks and silicious soil from the adjacent mountain, and is incapable of cultivation.

The several members preserve the general characters already given them. At Shade Gap the ore sandstone is seen on the road well exposed; but although minute search was made, no traces of the iron ore could be discovered. It may be fairly concluded that the fossiliferous ore does not exist in this belt.

The whole body of Surgent slates and Scalent marls lies more at the base of Shade Mountain as we approach its S.W. extremity, and there they meet the corresponding strata, which ranges at the base of Blacklog Mountain, folding over the axis at Littleton.

We shall next proceed to trace these slates and marls as they are found along the S.E. side of Juniata and Huntingdon counties.

Surgent Slates and Scalent Marls, Pfout's Valley.—This valley has been already described in connection with the geology of Perry County. The North-west-dipping strata, being separated from those inclined in an opposite direction by the emerging of the Levant white sandstone, extend from the N.W. side of Pfout's Valley, as far as Thompsontown, with a dip of 40° N.W. The S.E. limit of the Surgent slates is at the base of the Tuscarora Mountain, and the N.W. edge of the marls ranges a few hundred yards from the S.W. continuation of Turkey Ridge. The iron-sandstone belt forms the S.W. side of a ridge in the mouth of Pfout's Valley, and, extending across the Juniata, forms another hill close to the base of the mountain E. of Thompsontown. The red shales lie principally on the N.W. side of the river.

We made some search for ore in connection with the ore sandstone in the N.W. side of Pfout's Valley, but could not discover it. It is highly probable, however, that it exists, because it is found in the South-east-dipping strata near Millerstown. The proper place to look for it is *above* the white ore sandstone, perhaps 2 or 3 feet. The red or iron sandstone is well developed in this quarter, and can be seen exposed on the turnpike above the Tollgate.

Surgent Slates and Scalent Marls S.W. of Thompsontown.—Between Thompsontown and the Tuscarora Mountain, the whole belt lies with a N.W. dip in a zone about half a mile wide. Traced S.W., the margins diverge, the older slates ascend higher on the mountain, and the N.W. limit of the marls recedes from the base. This is caused by the introduction of the fourteenth anticlinal axis, which has been previously traced.

Between Thompsontown and the bend in the river below Mexico, the strata have three dips. The lower members, with a N.W. dip, crop out high on the flank of the mountain. Opposite Thompsontown the hard belt of iron sandstone forms several protuberances on the mountain-slope, but further S.W. it does not affect the surface. We have no evidence of iron ore. The anticlinal axis is on the N.W. side of the river, ranging in the marl group, the N.W. limit of which is a few hundred yards S.W. of the turnpike.

The synclinal axis is close to the foot of the mountain, and the Juniata flows along it. The channel of the river is much below the level of the formation N.W. of it.

The Surgent slates on the mountain are covered with loose rocks, and on the N.W. side of the river the surface is likewise much strewed with debris, left by the denuding current as it was checked by the Tuscarora Mountain. The anticlinal axis can be seen exposed in the excavations on the canal below Mexico.

Surgent Slates and Scalent Marls, S.E. Division of Tuscarora Valley.—Following the belt of these rocks across the Juniata below Mexico, we find it to occupy the S.E. division of Tuscarora Valley. It is, however, separated into two belts by a narrow tongue of limestone, which lies in the synclinal axis along the base of the mountain. Of these the most N.W., containing the anticlinal axis, extends S.W. for 13 or 14 miles, becoming more narrow and vanishing in a point on the farm of James McCullock, nearly opposite the S.W. end of the anticlinal Tuscarora Mountain, and half a mile from it. The N.W. limit of this belt ranges regularly at the distance of 200 or 300 yards from the base of the Limestone Ridge. Its S.E. edge is near the mountain. The zone thus traced is about three quarters of a mile wide, and forms the greater part of the S.E. division of Tuscarora Valley. It is not always distinctly separated from the belt nearer the mountain, for the narrow synclinal trough of limestone in some places disappears. It has a level surface, well adapted for cultivation, consisting entirely of the Surgent marl group.

Surgent Slates and Scalent Marls, N.W. Flank of Tuscarora Mountain.—The belt of these strata S.E. of the limestone below Mexico, ranges with considerable uniformity along the flank of the mountain to its termination. The rocks dip 60° to 70° N.W., the slates reaching high on the mountain, and forming the gentle slope of its base. The whole belt is entirely covered with debris, and does not admit of cultivation. The hard ore sandstone and associated ore, if this exists, crop out without affecting the evenness of the surface for many miles; but towards the S.W. end the sandstone appears in the form of a small broken ridge, close against the base of the mountain, and the whole slate group descends from the slope. This belt unites with the corresponding one of Liberty Valley, over the axis of Tuscarora Mountain, 2½ miles E. of Waterford.

The anticlinal axis of Tuscarora Mountain is prolonged for 13 miles S.W. of the end of the mountain, terminating 3 miles S.W. of the town of Waterloo. Between it and the monoclinal Tuscarora Mountain ranges a narrow synclinal trough, which may be considered as passing out of Liberty Valley. The Surgent belt, with three dips, extends from the mouth of Liberty Valley to the town of Waterloo, a distance of 10 miles. Its S.E. limit is on the flank of the mountain, and its S.W. edge some distance from the base, passing through the town of Waterford, and to the N.W. of Waterloo. The iron sandstone saddling the axis forms a broken ridge close along the base of the mountain, ending 5 miles S.W. of Waterford. Some search for ore was made along this line, but none was observed. The Scalent marls lie along the base of this ridge, having a dip N.W. In the synclinal axis between the ridge and mountain they are nearly excluded. When the ridge—or terrace rather, for it has that appearance—ends, the axis passes into the higher Scalent shales, and the formation is somewhat wider in connection with a curve in the mountain, affording the fine farming land E. of Waterloo.

A short distance S.W. of Waterloo the Scalent limestone is received in the synclinal trough near the base of the mountain, so that the Surgent marl belt becomes divided. The N.W. tract accompanying the anticlinal axis terminates in a point 1½ miles S.W. of Waterloo, opposite the gap, where it is saddled with limestone. The other extends along the base of the Tuscarora Mountain.

Surgent Slates and Scalent Marls S.W. of Waterloo, along the Tuscarora Mountain.—From a point S. of Waterloo to a point S.E. of the Burnt Cabins, the Surgent slates and marls occupy the flank and base of the mountain. The distance is between 16 and 17 miles. The strata are in a perpendicular attitude; their characters, as seen in the Waterloo Gap, correspond with the general description which has been given. The ore sandstone is from 30 to 40 feet thick, and the iron sandstone scarcely exists. Search was made for the fossiliferous ore, but it could not be found.

The strata under consideration follow the flexures of the mountain, resting high upon it. Their surface is entirely covered with loose rocks, and does not admit of cultivation.

S.E. of the Burnt Cabins, where the State Road crosses, the ore sandstone is connected with an irregularity of surface. This is the result of a local change of dip, the inclination being gentle; the slates below the sandstone have been scooped out by denudation, and a notch cut through the more resisting rock.

Opposite this point the belt unites with the same formation, developed by the several anticlinal axes E. of the Burnt Cabins.

Cove Anticlinal Axis and its Strata.—The anticlinal axis of the Cove originates in the Cadent black slate near the base of the Tuscarora Mountain, 5 miles N.E. of the Burnt Cabins. It diverges somewhat from parallelism with the mountain of Sydney's Knob.

Originating near the same point as the last, there are two short anticlinal axes between the Cove axis and the mountain. These are separated about 350 yards. They extend 3 or 4 miles, and die away in the mouth of the valley included between Sydney's Knob and the Tuscarora Mountain. The first *minor* axis, or the N.W. one, is 350 yards from the Cove axis, and parallel to it. The second is also parallel.

Surgent Slates and Scalent Marls, Cove Axis.—The Surgent marls emerge from beneath the overlying rocks along this axis in a narrow point, $2\frac{1}{4}$ miles N.E. of the Burnt Cabins, and with the slates form an expanding zone, extending to the base of Sydney's Knob. The first *minor axis* also elevates the marls opposite the same point, some distance to the S. of the Presbyterian Church, lifting a narrow tongue of red shale, which, 2 miles from its origin, coalesces with the same shales elevated by the Cove axis. This red shale belt also unites with the same formation, brought up by the second minor axis at a point which is a quarter of a mile S.W. of the State Road.

The second *minor axis* forms a narrow belt, extending along the base of the mountain. It originates half a mile S. of Neely's Sawmill. It is 200 or 300 yards wide and 3 miles long, ending by uniting with the belt brought up by the first axis on the N.W., and with the same formation occupying the mountain on the S.E. Three narrow tongues of limestone, which end some distance from the State Road, separate the several zones of the Surgent strata thus traced.

Thus the district which extends from the Burnt Cabins to the Tuscarora Mountain is entirely occupied by the Surgent and Scalent marls, traversed by the Cove axis on the N.W., and by the subdividing extremities of the second minor axis.

The iron and ore sandstones elevated by the Cove axis form a hill E. of the Burnt Cabins, but with this exception the surface is nearly level, and well cultivated.

As the Levant white sandstone rises in Sydney's Knob, the Surgent slate and marl belt branches into two; that on the N.W., with perpendicular strata, stretches along the N.W. base of Scrub Ridge, while that on the S.E. forms the tract of Surgent slates and marls between Cove and Tuscarora mountains. These rocks constitute a synclinal trough in the little valley included between the Cove Mountain, terminating in Sydney's Knob on the one side, and the Tuscarora Mountain on the other. This valley, which has no name, is drained by the Little Aughwick Creek, and is between 9 and 10 miles long, ending opposite McConnellsburg by gradually rising to the summit of the Cove Mountain. The slopes on each side meet at the stream in the centre of the valley; it is quite barren, being covered with the mountain debris. The Surgent slates and marls occupy the central portion of it, reaching one quarter of the height of the bounding mountains. On one side the dip is 50° N.W., and on the other 30° S.E. The ore sandstone is well developed, being 20 or 30 feet thick, but no iron ore could be found associated with it; if it does exist, it will be found, of course, along a double line of outcrop. The red shale lies in the middle of the valley, where the stream flows.

These rocks, gradually rising, crop out and terminate in the S.W. end of the valley, where it slopes up into the mountain.

CHAPTER IV.

SCALENT AND PRE-MERIDIAN LIMESTONES OF THE GENERAL TUSCARORA SYNCLINAL.

General Characters.—These two formations we shall trace as one mass. They are both remarkably uniform in their characters throughout the district. Their united thickness is several hundred feet. The Scalent limestone varies in its dimensions in different portions of the long and narrow tract, being at the Susquehanna River, in the axis of the Tuscarora Mountain, 200 feet thick, and expanding, though with some fluctuations, as it ranges S.W.

The Pre-meridian limestone, in like manner, thickens as it goes to the S.W., being 140 feet thick at the Tuscarora axis at the Susquehanna, and at least 250 feet in Fulton County. This rock is of a dull blue colour, breaking with irregular fracture, and it evidently contains some silex and alumina, which render portions of it not well adapted for making lime.

Above its fossiliferous layers the limestone is overlaid by beds of dark chert. This chert is a more important deposit towards the Susquehanna, becoming thinner in the other or S.W. direction. It should be grouped with the limestone, being characterised in the main by the same fossils. When the Pre-meridian limestone crops out its upper beds form the ridges, whilst the softer Scalent limestone has been more eroded, and extends along the base of the ridges.

Scalent and Pre-meridian Limestones S.E. of Shade Mountain.—From the immediate neighbourhood of Selinsgrove the South-east-dipping belt of the limestones, lifted by the Shade Mountain axis, extends S.W., and borders the little valley at the base of Chestnut Ridge and Shade Mountain. This, it was mentioned, is called Klopperdale and Heister's Valley.

The limestones underlie its S.E. side, and form its S.E. bounding ridge, which is called

Flintstone Ridge.—This ridge, from Middle Creek to Richfield, is nearly straight and unbroken, low and sharp-crested. The Cadent black slate lies on its S.E. flank, and the chert and Pre-meridian sandstone form its crest. The limestones compose its N.W. flank, and dip 25° S.E., and reach a few hundred yards from its base.

Scalent and Pre-meridian Limestone, Slenderdale Ridge Anticlinal Axis.—This axis, originating in the Cadent and Vergent rocks a few miles N.E. of Richfield, lifts out the Pre-meridian limestone a mile or more N.E. of that town. A short distance further the Scalent marl group is intruded, separating the limestones into two belts dipping in opposite directions. Of these the N.W. dips 60° N.W., and soon unites with the same formation of Heister's Valley, dipping S.E. A synclinal belt is thus formed, in which the upper and harder Pre-meridian limestone produces a low ridge, which is continuous with Flintstone Ridge, and terminates abruptly half a mile N.W. of Richfield. This forms, with the ridge passing S.E. of that town, an enclosed nook a mile and a half long.

The Scalent limestone of the synclinal axis terminates at a point half a mile S.W. of the end of the ridge.

Scalent and Pre-meridian Limestone, S.E. of Slenderdale Ridge Axis.—The village of Richfield is situated on the belt of limestone which the axis separates on the S.E. This outcrop extends in a straight line S.W. to M^cAllisterstown, a distance of 9 miles, with an uniform dip of 30° S.E. The Pre-meridian limestone, Meridian sandstone, and hard Cadent sandstone, produce a ridge also called *Flintstone Ridge.* This is low, and has a sharp crest, is cut in two places by the Mahantango and Cocolamus creeks, and forms with Shade Mountain and Slenderdale Ridge a valley already noticed. It terminates in a knob at M^cAllisterstown. The limestones occupy its N.W. flank, and a zone 300 or 400 yards wide along its base. The surface is much covered with chert, whence its name.

N.E. of McAllisterstown this belt unites with another outcrop, brought up by the Blacklog Valley axis.

Scalent and Pre-meridian Limestones, Blacklog Valley Axis.—The limestones rise to the surface along the Blacklog axis at McAllister's Mill, 3½ miles N.E. of the town. A narrow zone of the Meridian sandstone and Cadent black slate separates it from the belt just described. The rocks dip steeply on both sides of the anticlinal axis. Followed S.W., the formation becomes wider, and the strata over the axis are degraded into a little valley, closed towards the S.W., and opening between the two knobs E. of McAllisterstown. The strata N.W. of the axis meet the belt previously traced on the N.W. side of Flintstone Ridge, in a synclinal trough, separated from another short tract of limestone, S.E. of the anticlinal axis, by the intrusion of the Scalent marls.

The Pre-meridian limestone in the synclinal axis ends abruptly in a knob, the most N.E. of the two at McAllisterstown, while the Scalent limestone cut down extends half of a mile further S.W., ending in a point. From the end of the limestone S.W. of McAllisterstown to the Juniata River, the synclinal axis is entirely occupied by the red and other shales, but near the river the limestone is again embraced, extending for 5 miles S.W. into the valley of Licking Creek. Its reappearance is to be attributed to the sinking of the anticlinal axis of Slenderdale Ridge on its N.W. side..

This zone of limestone consists exclusively of the *Scalent limestone.* It may be seen on the E. side of the river, quarter of a mile above the mouth of Lost Creek. To the S.W. it is midway between the *Blue Ridge* and the *Forge Ridge.* It is level, and only 200 or 300 yards wide.

Scalent and Pre-meridian Limestones S.E. of McAllisterstown.—About half a mile S.E. of the Blacklog Valley axis, and three-quarters of a mile from McAllisterstown, there is a short anticlinal axis which elevates the limestone in a pointed belt, extending a mile or more N.E., between ridges of Meridian sandstone on each side. The North-west-dipping strata of this axis unite with those dipping in an opposite direction from the Blacklog axis, and they form a second synclinal knob in a line with, and half a mile S.E. of, that before described.

The South-east-dipping strata of the short axis are continued S.W. in Lost Creek Ridge. By the two axes S.E. of McAllisterstown the limestone is spread out so as to form an excellent agricultural tract. Small quantities of brown argillaceous iron ore have been found near the town ; but there is no reasonable probability that it occurs in quantity.

Scalent and Pre-meridian Limestones, Lost Creek Ridge.—It has been mentioned that two distinct ridges receive this name. The most S.E. bounds Lost Creek Valley, and contains the Pre-meridian, Meridian, and Cadent rocks. It extends from a point S.E. of McAllisterstown for 5 or 6 miles S.W., ending at the Cedar Spring. It is low and little broken, and is to be considered rather as the flank of a mass of ridges than a distinct ridge, for it is scarcely separated from the slate hills behind it.

The chert and Pre-meridian limestone compose the crest and flank, while the Scalent limestone forms a level zone 300 or 400 yards wide along its base. The strata dip 40° S.E.

This belt of limestone, bordering Lost Creek Valley, coalesces with another, extending from Kurtz's Valley along a synclinal line at Cedar Spring.

Scalent and Pre-meridian Limestones, Kurtz's Valley.—The limestones occupy the N.E. extremity of Kurtz's Valley, saddling its anticlinal axis. They penetrate a mile or more N.E. of the end of the valley, terminating in a point in that direction. The strata dip from the anticlinal line 30° or 40°. The limestones outcrop on the flanks of the ridges, and close up the valley at its S.E. end, forming there an irregular hill, the result of a local contortion. They separate into two belts, bordering the sides of the valley by the emerging of the Surgent marls along the axis.

Scalent and Pre-meridian Limestones of N.W. Side of Kurtz's Valley.—From Cedar Spring, where the more North-western of the Kurtz's Valley belts unites with the Lost Creek belt, the Scalent limestone extends in a narrowing synclinal strip for 10 or 11 miles S.W., crossing the Juniata at Mifflintown, and traversing the centre of the S.W. division of Tuscarora Valley.

From Cedar Spring to Mifflintown, the old road lies on this rock. It is widest at Cedar Spring, becoming narrower towards the river ; and S.W. of the river the belt never exceeds 200 or 300 yards in width. It becomes attenuated, and ends 7 miles S.W. of the Juniata. Its surface is entirely level, has a good soil, and affords a good supply of limestone to the neighbourhood.

Scalent and Pre-meridian Limestones, S.E. Side of Kurtz's Valley.—The S.E. belt of Kurtz's Valley is prolonged into that extending along the base of Shade Mountain, in Tuscarora and Little Aughwick valleys.

The limestones dip 30° or 40° S.E., ranging to the Juniata; the belt passes three-quarters of a mile or more N.W. of Mexico, W. of which it does not form a continuous ridge. It reaches the river at Perryville, which town is built upon it. Its width never exceeds a quarter of a mile.

S.W. of Perryville.—Pursuing this zone of limestone S.W. of the Juniata, it extends along the S.E. side of the middle division of Tuscarora Valley, throughout its entire length. From Perryville to Patterson's Mill, a distance of 5 or 6 miles, instead of lying in the flank of a ridge, the surface of the Pre-meridian limestone is entirely level, the bed of Tuscarora Creek being in many places upon it. The strata dip 30° S.E. From Patterson's Mill to M^cCoystown, 5 miles distant, the limestones occupy the same position along the S.E. side of the *middle division* of the Tuscarora Valley, the upper strata, however, forming, with the Meridian sandstone, a continuous ridge.

From McCoystown the belt extends S.W. in a straight line; approaching the base of Shade Mountain as the Kurtz Valley axis dies away S.W. of Cook's Gap, the Pre-meridian limestone and Meridian sandstone produce a low ridge, along the North-western base of which the *Scalent limestone* outcrops with a level surface.

The tract of limestone thus followed is too uniform to need a more particular description. From the river to the point where it reaches the mountain, the distance is 16 miles. The belt is 400 or 500 yards wide, its N.W. limit being in the centre of the middle division of Tuscarora Valley.

Scalent and Pre-meridian Limestones, S.E. of Shade Mountain.—From the point where the belt reaches the mountain near Cook's Gap, it extends S.W. along its base for 25 miles with great regularity, following the N.W. border of Tuscarora and Aughwick valleys. From Cook's Gap to Shade Gap the strata dip from 50° to 60° S.E. The N.W. limit is marked by the base of the mountain, and on the S.E. the Pre-meridian limestone forms with the Meridian sandstone a low broken ridge N.W. of Peru Mill, which is termed the *Barren Ridge.* Towards Shade Gap it is much less distinct, being merely a chain of knolls. The lower or *Scalent limestone* occupies a position along the N.W. base of this ridge, but is often so much covered with debris as not to admit of cultivation. It passes N.W. of Goosehorn's and Peru Mill.

Tracing it S.W. from Shade Gap, it retains the same relation to the mountain, but the Pre-meridian limestone does not form a ridge—it is entirely levelled, and nearly covered from sight with transported materials. The dip is steep, and we have therefore a narrow belt, which lies close to the mountain-slope.

Beyond the termination of Shade Mountain, this belt saddles the axis of Blacklog Valley west of Fort Littleton, doubling back with the belt which ranges in Great Aughwick Valley.

Scalent and Pre-meridian Limestones at the Mouth of Mahantango Creek.—The anticlinal axis of George's Valley, which crosses the Susquehanna at the mouth of the West Mahantango Creek, lifts the limestones there to the surface. This axis, extending 5 or 6 miles S.W. of the Susquehanna, dies away in the Cadent and Vergent rocks. The limestones appear for about 2 miles S.W. of the river, where they are saddled by the higher rocks. The belt is one-third of a mile wide, the N.W. limit being distinctly marked by a low ridge of chert. The strata dips 50° S.E. on one side, and 40° N.W. on the other. The surface is undulating, admitting of cultivation.

Scalent and Pre-meridian Limestones, N.W. Side of Pfout's Valley.—The limestones first appear in the extreme N.E. end of Pfout's Valley, 2 miles N.W. of Liverpool, and about 3 miles from the Susquehanna. They there form a narrow point saddled by the higher formations, and further S.W. they form the N.E. portion of Pfout's Valley, the chert layers being in the flanks of the bounding ridges. About 2½ miles from the E. end of the valley, the Scalent marls appear in its centre, and the limestone separates into two belts, one skirting each side.

The belt bordering Pfout's Valley on the N.W. dips 30° N.W. Its chert beds are in the S.E. flank of Turkey Ridge, which, as we shall see hereafter, is chiefly composed of the Cadent and Vergent rocks. The Scalent limestone lies along the base of that ridge, reaching several hundred yards into the valley. The chert is well exposed, and shows its characteristic fossils where Turkey Ridge is cut by the Cocolamus Creek. Followed S.W., the limestone stretches from the S.W. side of Pfout's Valley with great uniformity to the town of Mexico, a distance of 9 or 10 miles, in a narrow tract ranging near the base of a chain of hills of the Cadent grey sandstone. It is entirely degraded, and much covered by debris. Thompsontown, and the turnpike between that place and Mexico, lie upon it. It diverges somewhat from the Tuscarora Mountain, being at Mexico one mile from its base. The dip is 30° N.W.

Scalent and Pre-meridian Limestones, Limestone Ridge.—The belt we are now tracing crosses the Juniata at Mexico, and extends S.W. from the river, bordering the S.E. division of the Tuscarora Valley, and constituting the *Limestone Ridge.*

This ridge, from the river at Mexico to a point S.E. of Patterson's Mill, a distance of 7 miles, is uniformly about 120 feet high, and very straight, being only broken at one point. It is not separated from the Cadent slate hills N.W. of it by any continuous depression. Traced further to the S.W., it is less regular, but extends nearly in a straight line to Beale's Mill 12 or 13 miles from its origin, where it becomes indistinct. The crest and S.E flank of the Limestone Ridge is composed of the Pre-meridian limestone, the Scalent limestone reaching a few hundred yards from its base. The rocks near the Juniata dip 30° N.W., becoming steeper to the S.W.

The belt thus described is one-fourth of a mile wide. It passes three-fourths of a mile S.E. of Perryville, and a mile S.E. of Patterson's Mill, where it is crossed by the Creek in one of its flexures. It is about 1¼ miles from the base of the Tuscarora Mountain. N.E. of Beale's Mill it unites over the fourth anticlinal axis with the other belt of the same rocks in the synclinal axis S.E. of it.

Scalent Limestone, Synclinal Axis between the Tuscarora Mountain and Fourth or S.E. Anticlinal Axis.—Where the Juniata reaches the base of the mountain 1½ miles below Mexico, strata of the Pre-meridian limestone are observable in this synclinal axis; thence S.W. for 8 miles, a considerable belt occupies the trough. This extends close along the base of the Tuscarora Mountain, and dips 30° S.E. and 60° N.W. The limestone is 200 or 300 yards wide, and degraded, and is so completely buried under debris that the rock is rarely seen, although it may be readily traced by the sink-holes on the surface. About 8 miles from the river it becomes alternated, and lifted out of the synclinal axis from a slight elevation of the whole trough. The very lowest strata are seen in patches, at intervals, for several miles near the *Mountain Road.*

About 2 miles N.E. of Beale's Mill, the limestone reappears in the synclinal axis, and widens out to the S.W., so that, at last, the Pre-meridian limestone comes in, forming the short ridge which rises on the farm of James McCullock, and extends to Laurel Run below Beale's Mill. There is a small depression between this and the Limestone Ridge, through which the fourth anticlinal axis passes, and where the limestone folds over the attenuated point of the Scalent marls on that axis.

On Laurel Run, below Beale's Mill, the limestone has three dips; but not far S.W. of that stream, Pre-meridian limestone and Meridian sandstone occupy the synclinal trough and overlie the anticlinal axis, and thence S.W. the limestone ranges with a single N.W. dip.

Scalent and Pre-meridian Limestones, passing Waterford and Waterloo.—From near Laurel Run to a point 1½ miles S.W. of Waterloo, the limestones stretch in a straight line in a narrow belt, perhaps less than 400 yards wide, with a dip 45° N.W. They pass close to the N.W. of the town of Waterford, and one-fourth of a mile N.W. of Waterloo, being a considerable distance from the base of the mountain. Its N.W. limit is near the S.E. base of a ridge of the Cadent sandstone, which runs with great regularity. In all this distance the outcrop is generally level, the channel of the Creek being on it. At a few points, the Upper or Pre-meridian limestone, together with the Meridian sandstone, form hills, but these are widely separated and insignificant.

The limestone has its usual characters. Dark chert occurs in considerable thickness, and is seen well exposed at the Waterford Bridge.

S.W. of Waterloo.—It has been mentioned that the axis of Tuscarora Mountain, prolonged, extends near Waterloo in the Scalent marls. Here, in the synclinal axis between it and the mountain, the Scalent limestone appears a short distance S.W. of the town, close to the base of the mountain, being well exposed at the Fulling Mill near the Gap. The dip is steep.

Immediately opposite the gap, the Pre-meridian limestone enters the synclinal trough, and forms a hill which is capped by the Meridian sandstone. It is therefore separated into two zones, that on the S.E. extending along the mountain many miles S.W., while the other unites, over the axis of Tuscarora Mountain, with the belt which we have traced as passing N.W. of Waterloo. This takes place opposite Waterloo Gap, and 1½ miles S.W. of the town. From the point of union, the axis, which is now in the limestone, extends half a mile further S.W., when the higher formations fold over it on the N.W. side of the mountain-road, and conceal the limestone.

S.W. of Waterloo Gap.—The limestone extends from the Gap south-west for 11 or 12 miles along the base of the mountain in an uninterrupted line, with a steep N.W. dip. It is a narrow tract, and for the most part buried by debris. It is close to the foot of the mountain, and its S.E. limit is pretty accurately marked by the main road. The Pre-meridian limestone and Meridian sandstone compose, together, a low broken ridge for 4 or 5 miles, but this becomes indistinct to the S.W. This belt meets with others between 4 and 5 miles N.E. of the Burnt Cabins, brought to the surface by anticlinal axes.

The Cove axis and the two Minor axes, which have been already noticed, originate nearly together about 4 miles N.E. of the Burnt Cabins, and throw the Scalent limestone into several slender tongues.

The second or S.E. small axis elevates the Scalent marls to the surface one-third of a mile S. of Neely's Sawmill, from which point S.W. a slender zone of limestone extends in the synclinal axis between it and the mountain. This limestone lies close along the foot of the mountain, becoming attenuated, and ending at the State Road which goes to Fannettsburg. It is almost entirely covered with debris. This belt is continuous with that which has been traced from Waterloo Gap.

S.W. of Neely's Sawmill there is an irregular hill or ridge of the Pre-meridian limestone and Meridian sandstone, which contains the Cove axis and the first Minor axis in the limestone, and causes narrow tongues of the Meridian sandstone to occupy the intervening troughs. The manner in which these axes elevate the Surgent marls has been already described.

The Scalent limestone runs in narrow strips S.W. of the knolls of sandstone, one slender belt extending 2 miles between the two short axes, and ending half a mile N.E. of the State Road, while another, between the first Minor axis and the Cove axis, extends from the Presbyterian Church for 1½ miles S.W. The three tongues of the Scalent limestone are only a few hundred yards apart, underlying the level district which is E. of the Burnt Cabins.

Scalent and Pre-meridian Limestones N.W. of Cove Axis.—The limestone belt separated on the N.W. side of the Cove axis by the intrusion of the Scalent marls, has a perpendicular dip, and is consequently quite narrow. It extends from the separation in a straight line S.W., passing a short distance N.W. of the Burnt Cabins to the N.W. base of Sydney's Knob, the upper harder Pre-meridian strata forming several hills. The rocks have the general characters before given them. This belt extends along the base of Little Scrub Ridge as far as the commencement of the fault, in which it disappears opposite the end of Big Scrub Ridge, as already described.

Pre-meridian Chert between Tuscarora Mountain and Shade and Blacklog Mountains.—In the S.E. part of Union, and the E. part of Juniata counties, the chert forms the small ridges usually capped by the Pre-meridian sandstone. It is here of a dark colour, and varies from 15 to 40 feet in thickness. Its fossils are chiefly those of the limestone on which it rests. The outcrop of the chert coincides almost exactly with that of the Pre-meridian sandstone. The two rocks will be traced in connection.

CHAPTER V.

MERIDIAN SANDSTONE IN THE THIRD OR TUSCARORA SYNCLINAL.

GENERAL CHARACTERS.

The Meridian sandstone is of insignificant thickness throughout the whole district under consideration. In the S.E. part of Union and the E. part of Juniata counties it is sometimes entirely absent. In the S.W. portion of Juniata County, and Dublin and Tell townships, Huntingdon County, the sandstone is more frequently visible ; still, however, its thickness is inconsiderable.

Distribution of the Meridian Sandstone.—From the thinness of the formation little more than a cursory sketch of the several ranges is here required. Indeed, the whole outcrop has been already given in detail in tracing the limestones.

Pre-meridian Chert, Flintstone Ridge.—The chert beds form the crest of the Flintstone Ridge. This ridge extends from Middle Creek W. of Selinsgrove to McAllisterstown, a distance of 21 miles. It is, however, broken by the passage of the Slenderdale Ridge axis, at Richfield, in the manner described, a synclinal tongue of the formation being prolonged for some distance on the N.W. side of the axis.

No true Meridian *sandstone* was observed along the whole extent of Flintstone Ridge, and it may therefore be considered as not existing. Its inclination has been given in connection with the limestones.

The *Blacklog Valley axis* brings to the surface the chert beds at McAllister's Mill, 4 miles N.E. of McAllisterstown. These extend S.W. in two zones, dipping in opposite directions. Those on the N.W. form, with the same beds of *Flintstone Ridge,* a synclinal axis, embracing the Cadent and Vergent rocks, ending in the N.E. knob at McAllisterstown.

The chert E. of the Blacklog axis extends S.W., and terminates in the second synclinal knob S.E. of the town, by meeting with the corresponding beds dipping in an opposite direction from the short axis existing there.

This short axis first brings to the surface the chert beds, a mile or more N.E. of the second knob, in which those of the N.W. side terminate, cropping out on its crest. The same layers extend in another outcrop along the crest of Lost Creek Ridge, terminating at Cedar Spring.

Chert in Kurtz's Valley.—The chert forms the brow of the bounding ridges of Kurtz's Valley. It emerges one mile from the N.E. end of the valley, from the overlying Cadent and Vergent rocks. The North-west-dipping strata unite at Cedar Spring with the same rocks of the Lost Creek Ridge, and there crop out.

The chert with a S.E. dip extends along the flank of the S.E. ridge of Kurtz's Valley, leaving which, it passes three-quarters of a mile N.W. of Mexico, and reaches the Juniata at Perryville. No sandstone is here discoverable.

Chert in the Middle Division of Tuscarora Valley.—From Perryville the chert—the sandstone being absent—extends along the S.E side of the middle division of Tuscarora Valley. As far as Patterson's Valley Mill its outcrop is completely levelled, but S.W. of that it is to be found in the crest of the low broken ridge which bounds this division of the valley. McCoystown is situated on it. S.W. of Cook's Gap it approaches nearer the base of Shade Mountain. In all this distance no Meridian sandstone was observed. The inclination of the beds has been given in connection with the description of the limestones.

Meridian Sandstone and Chert S.E. of Shade Mountain.—Along the S.E. base of Shade Mountain both rocks occur, beds of coarse sandstone or fine conglomerate reposing on the chert. The thickness of the former is inconsiderable, and the Pre-meridian limestone produces a low broken ridge, the more continuous part of which, extending N.W. of the Peru Mill, has been termed the Barren Ridge. S.W. of the Barren Ridge the Pre-meridian limestone, chert, and sandstone, produce occasional hills or short ridges on the line of their outcrop.

S.W. of Shade Gap, these strata continue with the same characters close along the base of the Shade Mountain, having a steep S.E. dip. Where the Shade Mountain terminates, the belt passes to the S.E. of Fort Littleton, becoming a thicker deposit, until it unites over the axis with the zone extending along the foot of Blacklog Mountain.

Chert at the Mouth of Mahantango Creek.—The axis at the mouth of the Mahantango Creek elevates the chert beds in a double line of outcrop. That on the N.W. side is crossed by the Susquehanna below the Half Falls, from whence it passes 2 miles S.W., until it folds over the axis, meeting with the other belt. It produces a low ridge, on which the chert is profusely scattered in loose fragments. The Creek cuts through this ridge. The chert, with a S.E. dip, has its outcrop levelled. This belt is about half a mile from the other, and terminates by meeting and sinking under the Cadent and Vergent rocks. No sandstone exists in it.

Chert in Pfout's Valley.—The chert beds occur in Pfout's Valley, but there is no sandstone. They emerge from beneath the Cadent black slate, along the axis of Pfout's Valley, 2 miles N.W. of Liverpool, and 3 miles from the Susquehanna, in the line of direction of the axis. The rock immediately separates into two oppositely-inclined belts, occupying the flanks of the ridges bounding the valley ; that on the N.W. crops out on the flank of Turkey Ridge, about half-way from its crest. As seen in Turkey Ridge, where cut by Cocolamus Creek, it is 40 or 50 feet thick, is dark-coloured, and has a knotty irregular surface. The upper layers contain the characteristic fossil of the Pre-meridian limestone, the *Delthyris macropleura*, very abundantly.

From the N.W. side of Pfout's Valley the belt extends S.W., passing Thompsontown, and reaching the Juniata River at Mexico. It lies along the base of the ridge of Cadent and Vergent rocks. The turnpike from Thompsontown to Mexico marks its position very nearly. Its surface is entirely level. It can be seen on the canal a few hundred yards from Mexico, dipping 40° N.W.

Meridian Sandstone and Chert, Limestone Ridge.—The Limestone Ridge has been described. Its crest is composed of chert and a thin bed of the sandstone. These strata dip to the N.W. from 40° to 60°. The belt in the Limestone Ridge is a continuation of that traced from the N.W. side of Pfout's Valley ; it is crossed by the Juniata at Mexico, and prolonged thence uniformly to a point opposite the end of Tuscarora Mountain, 14 miles distant. It there folds over the *fourth or S.E. axis*, half a mile W. of Beale's Mill. The sandstone does not occupy the synclinal axis between the fourth anticlinal and the mountain, and the belt therefore merely receives a flexure as it saddles it, and then extends on S.W., dipping to the N.W.

Meridian Sandstone and Chert, N.W. of Waterford and Waterloo.—From the point where the thin sandstone saddles the axis W. of Beale's Mill, it is traceable in a straight direction S.W. for 12½ miles, with a rather uniform dip 45° N.W. In this range it passes N.W. of Waterford and Waterloo, extending close to the base of the Cadent and Vergent ridges. Its outcrop is generally degraded, forming, with the upper strata of the Pre-meridian limestone, detached hills at a few points, but the bed of the Creek nearly represents its course. The sandstone is seen well exposed near Waterford at the bridge, where it consists of beds of coarse calcareous sandstone, replete with the usual fossils. It is blue, turning by exposure to a dull brown. It is 20 feet thick, and overlies dark chert and silicious limestone. Following this zone beyond Waterloo, it folds over the prolonged axis of Tuscarora Mountain, about 2 miles S.W. of that town.

Directly at the Waterloo Gap, the sandstone is first embraced in the synclinal axis between the prolonged axis of Tuscarora Mountain and the Mountain on the S.E. It there caps a hill close to the base of the mountain, consisting of layers of sandstone and chert. Nearly one mile W. of the gap the Cadent black slates are received in the synclinal trough, where the South-east-dipping strata soon unite with those of the opposite inclination already traced, and they sink under the overlying rocks.

The North-west-dipping belt extends uniformly for 11 miles S.W., at a few hundred yards' distance from the base of the mountain. Its range is nearly marked by the main road, from its separation to Neely's Sawmill, where the Cove axis originates. It consists of a few beds of coarse calcareous sandstone, which, on the weathered surfaces, is brown and ferruginous. The formation in connection with the Pre-meridian limestone produces a chain of low hills for 5 or 6 miles S.W. from the Waterloo Gap. Further S.W. it is completely levelled.

S.E. of Neely's Sawmill, 4 miles E. of the Burnt Cabins, the Cove axis and the two lower axes throw the sandstone into several slender belts. The formation does not enter the trough between the second small axis and the mountain, but it extends in two slender tongues, one between the Cove axis and the first lesser axis, and the other between the two lesser axes. These, which are only 100 yards apart, occupy the S.E. part of the crest of the hill or ridge lying between Neely's Sawmill and the Presbyterian Church, 1½ miles distant. The most N.W. is the longest, reaching nearly to the end of the ridge; the other ends a quarter of a mile to the E. of the former. The crest of the ridge, as formed by these belts, is rocky and barren, the intermediate tongue of limestone being covered by fragments of the sandstone, which is here a coarse brown sandstone, highly impregnated with iron.

The Meridian Sandstone.—This rock, separated on the N.W. side of the Cove axis, extends with a perpendicular dip from near Neely's Sawmill south-west in a straight line. It passes a few hundred yards N.W. of the Burnt Cabins, and follows the base of Little Scrub Ridge, becoming involved in the fault. It lies in the N.W. side of the ridge E. of Neely's Sawmill, between which and the Burnt Cabins it forms several other hills.

CHAPTER VI.

CADENT AND VERGENT ROCKS OF THE THIRD OR TUSCARORA SYNCLINAL.

GENERAL CHARACTERS.

The Cadent black slate and the included argillaceous limestone retain their features and dimensions with little variation as we trace them S.W. The principal modification is the coming in of the stratum of carbonate of iron above the limestone as the formation advances in that direction.

The composition and relative expansion of the several formations of the Cadent series in the district under review, does not depart essentially from the type displayed near the Half-Fall Mountain, in the district next S.E. The chief deviation is the Cadent shale group, which, from the condition of a hard, coarse, grey argillaceous sandstone, has become, in this more N.W. tract, a softer and more argillaceous rock, of a somewhat diminished thickness.

No iron ore could be detected in Juniata and Union counties, but in the S.E. portion of Huntingdon County it occurs in precisely the same position and character as the ore found in Little Cove. The original deposit is in the form of a blue protocarbonate, but by exposure this has been partially converted into a brown peroxide. This will be particularly noticed in connection with the localities visited. It agrees in every respect with the descriptions already given.

Above the black slate we find as usual the Cadent shale, here still possessing the character of an argillaceous sandstone, which, from its relative hardness—its actual hardness is not excessive—affects the physical features of the whole district. It consists chiefly of a grey or greenish tough argillaceous sandstone, of coarse texture, in massive beds.

Next the N.W. side of the district there are very massive beds of a softer brown sandstone above the harder variety, which latter contains a profusion of large fossils. This softer member occurs N.W. of Pfout's Valley. It is, however, rather local, and the prevailing character is that which has been given above.

On the Susquehanna the lower harder rock is from 100 to 150 feet thick, but its thickness diminishes in the W. part of Juniata County and the S.E. townships of Huntingdon.

It usually forms continuous ridges along its outcrop. Thus, then, the country between the Tuscarora Mountain and Shade Mountain seems to be the quarter where the second Cadent group undergoes its passage from a S.E. to a N.W. type, by the rapid thinning-out of the hard sandstone, and coming in of softer shales upon it.

Above these sandstones lie the Vergent shales, consisting of the alternation of shales and grey sandstones, as described in the adjacent district on the S.E. Its thickness could not be estimated, but it evidently approximates to that which the group possesses near the Half-Fall axis. The reader is referred to the vertical section for that locality.

Distribution of the Cadent and Vergent Rocks.—In the general valley included between the Shade and Tuscarora mountains the Cadent and Vergent rocks are spread out to a great extent at each extremity, forming an unproductive surface, while in the intermediate portion of the valley the lower formations are elevated, so as to form the rich agricultural districts of Tuscarora and Lost Creek valleys.

A narrow synclinal zone extends along the centre of the district, uniting the two wide tracts of the N.E. and S.W. portions. Between Selinsgrove and M^cKey's Half-Falls, the Susquehanna flows across a general synclinal basin, a prolongation of that of the Shamokin coal-field. The river sweeps by the end of the Mahanoy Mountain, crossing the synclinal axis in a diagonal direction.

The Ponent red sandstone occupies a triangular tract centrally between the axis at Selinsgrove and the George's Valley axis, ending in a point 6 or 7 miles W. of the river, and upon each side of the basin the Cadent and Vergent rocks crop out in broad belts, which meet along the synclinal line S.W. of the termination of the Ponent red sandstone.

Cadent and Vergent Rocks S. of Selinsgrove.—Selinsgrove is near the N.W. border of the Cadent and Vergent tract, which extends S.W. from that place in a belt $1\frac{1}{2}$ miles wide. The S.E. limit is quarter of a mile above the mouth of Penn's Creek, and the zone extends 6 or 7 miles S.W. from the river before it joins that on the S.E. It forms a hilly sterile surface in Chapman and Washington townships, Union County. Its N.W. limit is on the flank of Flintstone Ridge. The dip is 30° S.E.

Cadent and Vergent Rocks, N. of McKey's Half-Falls.—The wide tract on the S.E. side of the Ponent red sandstone is bounded by that formation on the N.W. and by the Meridian sandstone, elevated by the axis at the mouth of the Mahantango Creek. Its N.W. limit is on the Susquehanna, 5 miles above McKey's Falls. The strata dip 40° N.W. This belt unites on the N.W. with the oppositely-dipping belt already noticed. On the S.E., about $1\frac{1}{2}$ miles S.W. of the river, it folds over the anticlinal axis which passes the mouth of the Mahantango. The tract, which is more than 2 miles wide, lies chiefly in Chapman and Perry townships, Union County. The sandstone in the lower part forms McKey's Half-Falls and a ridge to the S.W.

Cadent and Vergent Rocks S.E. of the Mouth of Mahantango Creek.—From the mouth of the W. Mahantango Creek the Susquehanna flows upon the rocks diagonally to their strike for 3 miles or more. This belt unites on the N.W. over the Mahantango Creek axis with that just described; its S.E. limit is at the river, $2\frac{1}{2}$ miles above Liverpool. Along the river the strata dip 40° or 50° S.E. uniformly, but to the S.W. the axis of the Tuscarora Mountain, rising, elevates the Cadent and Vergent rocks in the E. end of Pfout's Valley, separating the belt into two divisions, the S.E. one forming *Wildcat Ridge and Valley,* already described; the N.W. one coalescing S.W. with the wide district N.W. of Pfout's Valley.

Cadent and Vergent Rocks between Pfout's Valley and Flintstone Ridge.—The Cadent and Vergent strata, occupying the S.E. portion of Perry Township, Union County, and a large portion of Greenwood Township in Juniata County, lie between Pfout's Valley on the S.E. and Flintstone Ridge on the N.W. Their breadth is between 5 and 6 miles. They are spread out by the several anticlinal axes which have been described. The axis passing the mouth of the Mahantango flattens down in the S.E. side of the tract. To the N.W., the Slenderdale Ridge axis, the Blacklog Valley axis, the short axis S.E. of McAllisterstown, and the Kurtz Valley axis, all originate in this tract, and, as they pass out S.W. into higher formations, throw these into synclinal tongues or triangular areas, which become narrow, and then terminate to the S.W.

In its external features this is a country with a poor soil, and traversed by numerous irregular ridges. It is drained by the W. Mahantango and Cocolamus creeks. It contains no mineral of value, although the presence of black slates has led at times to a delusive search for coals.

From Middle Creek to Richfield, the limit of the Cadent and Vergent rocks, is an unbroken line on the S. side of Flintstone Ridge. The Slenderdale Ridge axis rises in it, lifting to the surface the Pre-meridian limestone 1½ miles N.E. of Richfield, by which a slender synclinal belt of the Cadent black slate is isolated on the N.W. of the main body. This extends about a mile. The boundary of this chief belt ranges from the emerging of the axis mentioned to McAllister's Mill, still following the S.E. flank of Flintstone Ridge. At McAllister's Mill the Blacklog Valley axis elevates to the surface the Cadent and Vergent formations, and separates on the N.W. a narrow synclinal trough, which is several hundred yards wide, and extends between 2 and 3 miles S.W., ending on the top of Flintstone Ridge, 1 mile S.W. of McAllisterstown.

The short anticlinal axis, one mile E. of McAllisterstown, forms between it and the Blacklog Valley axis a short basin of the Cadent slates, which end in a point on the second bluff E. of McAllisterstown.

Cadent and Vergent Rocks, Kurtz Valley Anticlinal Axis.—This axis first elevates to the surface the Meridian sandstone, and then the Pre-meridian limestone, rather more than one mile N.E of the road from McAllisterstown to Thomastown, separating the main body of Cadent and Vergent rocks into two nearly equal synclinal basins. Of these the N.W. one, where the road just alluded to crosses it, is one mile wide. It extends 6 miles to the S.W., gradually growing narrower until it ends in a point N.E. of Cedar Spring. It forms the area between the Lost Creek Ridge on the N.W. and the bounding ridge of Kurtz's Valley on the S.E. Its limits are near the summits of these ridges. The rocks of this synclinal trough dip 50° S.E. and 25° N.W. It has a hilly surface and a thin soil.

The S.E. portion of the wide district which lies immediately N.W. of Pfout's Valley, is called *Turkey Valley*, a vaguely-defined area, traversed by the ridges and hills characteristic of the formation, and drained by Cocolamus Creek. It is bounded on the S.E. by Turkey Ridge, which separates it from Pfout's Valley.

Turkey Ridge.—This originates with Wildcat Ridge, 3 miles from the Susquehanna, in a line with the strike of the rocks, the two ridges diverging and enclosing Pfout's Valley. Turkey Ridge is perhaps 150 feet high, and is straight. It is 10 or 11 miles long, and becomes lower towards Thompsontown, where it loses its distinctive appellation. It is notched at the passage of the Cocolamus Creek. Its crest and N.W. flank consist of the Cadent grey sandstone in very massive strata, dipping 35° N.W. The black slate and limestone crop out upon the S.E. flank.

Along its N.W. flank and base there crop out some heavy strata of a soft coarse brown and white sandstone. This rock is but a subdivision of the Cadent grey sandstone, being filled with a profusion of the same large spirifers and other fossils. It is seen well exposed on the Cocolamus Creek, and may also be observed in the Susquehanna, below the mouth of the Mahantango, but at no other point.

Where the Kurtz Valley anticlinal axis elevates the Meridian sandstone, it insulates to the S.E. a long synclinal basin of the Cadent rocks, which, opposite Thompsontown, is 1½ miles wide. It is this belt which, extending through the middle of Juniata County, forms a communication with the same formation in Tuscarora and Little Aughwick Valleys. The S.E. limit of this basin extends from Thompsontown to Mexico, and is marked by the ridge or chain of hills seen N.W. of the Turnpike, and which is continuous with Turkey Ridge.

The N.W. limit coincides in a similar manner with the S.E. bounding ridge of Kurtz's Valley, and the space between is filled up with irregular hills of the Vergent shale. The rocks dip 40° N.W. and 40° S.E. The existence of the exterior ridges is due to the grey sandstone.

This synclinal belt becomes narrower as it extends S.W., being at Mexico, which is on its S.E. border, only about three-fourths of a mile wide. Following it S.W. from Mexico, we find the Juniata River flowing in it below Perryville, the stream there washing the base of the Limestone Ridge.

Cadent and Vergent Rocks S.W. of the Juniata.—Pursuing the belt S.W. of the Juniata, it forms S.E. of Perryville, which is near its border, a mass of ridges, of which the Limestone Ridge is the S.E. limit. Its width is about half a mile, and the dip 45° S.E. and 30° N.W., making a very regular synclinal trough.

About three-fourths of a mile S.W. of Perryville, excavations have been made in the black slate in search of *coal.* The slate is highly carbonaceous and shining—features likely to deceive those who are ignorant of the characters distinctive of the coal slates.

S.W. of Perryville.—From the Juniata at Perryville to Patterson's Mill, 5 or 6 miles distant, the same general conditions continue. The S.E. limit is indicated by the Limestone Ridge, on the flank of which the bottom strata of the Cadent and Vergent series rest. N.W. of the Limestone Ridge, these strata form a zone of irregular hills, bounding the middle division of Tuscarora Valley on the S.E. As the Pre-meridian limestone and Meridian sandstone are levelled to the general plain, the Creek, in its windings, flows at several points over the black slate. In the neighbourhood no distinction is made between the slate hills and the Limestone Ridge, truly so called, since there is no continuous depression between them ; and the whole mass bounding this division of the valley may be considered as one ridge. The synclinal trough or belt of Cadent and Vergent rocks opposite Patterson's Mill, which is a few hundred yards from its border, is three-fourths of a mile wide. S.W. of the Mill it is twice completely crossed by the Creek, and a portion included in the bend is level with the surface.

Following the tract S.W., it gradually widens, the N.W. limit approaching nearer the Shade Mountain, as the *Kurtz Valley axis* dies away, and the S.E. limit approaching the Tuscarora Mountain, so that at a point opposite Beale's Mill it is at least 2½ miles wide, and occupies all the central part of Tuscarora Valley. Its limits are well defined by the ridge of Meridian sandstone and Pre-meridian limestone already described, and between these the surface presents the irregular hills so peculiar to the formation.

Where the fourth or S.E. anticlinal axis is saddled by this formation W. of Beale's Mill, there is no tongue of slate entering the narrow synclinal trough to the S.E. of it, owing to its little breadth, but merely a short offset produced in the edge of the black slate, the S.E. limit of which approximates somewhat nearer to the mountain.

Cadent and Vergent Rocks—the S.W. extremity of Tuscarora Valley and Little Aughwick Valley.—From the line where the formation reaches its maximum breadth—which is between the end of the anticlinal Tuscarora Mountain and Cook's Gap in Shade Mountain, or thereabout—we trace it S.W. in one broad zone for many miles. It forms all the central portion of the S.W. end of Tuscarora Valley, and of the Little Aughwick Valley, and, stretching into Fulton County, passes on as the belt N.W. of Little Scrub Ridge.

This tract, which may be conveniently described entire, is 26 or 27 miles long, and has an average width of 2½ or 3 miles. It is regularly synclinal, the only irregularities being connected with the passage of the Tuscarora Mountain axis into its S.E. border near Waterloo, and the origin of the Cove axis, and the two lower axes E. of the Burnt Cabins. Its N.W. limit is a nearly straight line, parallel to the Shade Mountain, and a quarter of a mile from its base. The S.E. limit, which is near the base of Tuscarora Mountain, has been shown in tracing the outcrop of the strata.

The Cadent black slate crops out on each side of the general synclinal belt, at the base of continuous ridges formed of the greenish-grey sandstone.

On the N.W. side, we find these slates, which vary from olive to black, several hundred feet thick, occupying a narrow valley or hollow between the ridges of Cadent sandstone and of Meridian sandstone, when this latter exists. The limestone of the slate is also found here, consisting of a few strata of dingy blue argillaceous limestone, about 100 feet above the Meridian sandstone.

Approaching Shade Gap in Huntingdon County, the iron ore of the black slate begins to appear. It was not detected by us E. of Shade Gap, although it probably extends some distance in that direction. It lies a few feet above the limestone beds, cropping out 100 or 200 yards from the base of the ridge of Cadent grey sandstone.

Iron Ore.—This ore was originally opened near Blain's, at Shade Gap. It is there in the form of a stratum, from 2 to 4 feet thick, of the argillaceous protocarbonate of iron, of a blue colour. It is encrusted with the chestnut-coloured hydrated peroxide, and precisely resembles the ore found in a similar position N.W. of Blacklog Mountain.

Following the range S.W., ore is observed on the surface at several points distant from Shade Gap, and it no doubt accompanies the formation into Fulton County, passing S.E. of Littleton. Its relation to the exterior ridge of Cadent grey sandstone, from the base of which it is several hundred yards distant, will prove a guide to its exact position.

The Cadent lower black slate, as it crops out on the S.E. side of the synclinal belt, has the same characters as on the other side. From Beale's Mill to a point 1½ miles S.W. of Waterloo, the formation lies at the base of the ridge of grey sandstone, which is very regular. The bed of the Creek is frequently in the slate. It is well exposed at the Waterford Bridge with its limestone; the whole dipping 45° N.W.

Opposite the Waterloo Gap, or a little S.W., the subsiding extremity of the Tuscarora Mountain axis passes into the Cadent black slate, which saddles it, and extends in an insignificant strip into the synclinal axis S.E. of it. The anticlinal axis dies away in this black slate, having merely the effect of spreading it out a little more at the base of the grey sandstone ridge.

From the Waterloo Gap to the origin of the Cove axis, 10 or 11 miles distant, the Cadent black slate extends uniformly at the base of the ridge of grey sandstone, its S.E. limit being nearly indicated by the course of the main road. We find, likewise, that indications of the stratified ore begin to appear on the surface. Fragments were observed on the farms 6 or 7 miles from the Burnt Cabins, near the main road. The ore is to be found, no doubt, associated with the limestone layers as usual. It was not at the time of the Survey opened at any point along this range. It is easily discoverable by reference to the limits of the Slate formation.

Where the Cove axis and the two short axes S.E. of it rise, the black slate enters in two slender tongues, one between the first and second minor axes, and another between the Cove axis and the first. These are quite insignificant belts, occupying the S.E. crest of the ridge S.W. of Neely's Sawmill.

The main Cadent belt extends on the N.W. side of the Cove axis, the black slate continuing along the base of the ridge of grey sandstone. This strip of black slate passes N.W. of the Burnt Cabins, and draws near the foot of the Little Scrub Ridge, which it follows South-westward.

It was before mentioned that the grey and greenish sandstone in the lower part of the Cadent series produces ridges which are very distinct and regular, though generally destitute of special names. That on the N.W. of this long belt, consisting of South-east-dipping strata, can be traced continuously, or nearly so, from opposite Cook's Gap, South-westward to the end of Shade Mountain. Steep, barren, and covered with a growth of pine, it is cut down by denudation opposite Shade Gap, but S.W. of that it is well marked.

The corresponding ridge on the S.E. of the basin is equally regular, extending in a line (only broken by gaps at wide intervals) from opposite Beale's Mill to the Burnt Cabins. It is the ridge seen N.W. of Waterford and Waterloo, and N.W. of the main road from the latter place to the Burnt Cabins. Diverging from the Tuscarora Mountain as the Cove axis rises, it extends towards the base of Scrub Ridge, between which and the Shade Mountain the synclinal trough of Cadent and Vergent rocks contracts in breadth.

Between the exterior ridges the upper formation, or Vergent shale, forms a hilly surface with a poor soil, comprising a large part of Lack Township in Juniata County, and Dublin and Tell townships in Huntingdon County. These ridges have generally no determinate form. There is, however, a more regular and higher ridge, occupying the middle of the belt opposite Waterford and Waterloo. It rises 2 miles S.W. of M^cCullock's Mill, and ends 11 or 12 miles distant, opposite Waterloo Gap, and consists of hard sandstone and shale, embraced in the centre of the synclinal trough. The ridge is double, enclosing a slender elevated valley. Alternations of pink-coloured and brown shales show that the strata belong to the upper harder part of the Vergent shale group. This ridge and the two exterior ones are much higher than the intermediate irregular hills of the middle part of the belt. Near the mountains the dip on both sides of the synclinal axis is from 40° to 50°, but it becomes gradually gentler as the synclinal line is approached.

Ponent Red Sandstone on the Susquehanna.—The Ponent red sandstone lies, as already stated, in a triangular tract in the middle of the general basin on the Susquehanna, below Selinsgrove. The strata dip 40° N.W. on one side, and 30° S.E. on the other. On the river the tract is 2 miles wide, its N.W. limit being above the mouth of Penn's Creek. It extends S.W. between 6 and 7 miles, becoming narrower, and finally verging to a point, near the E. branch of W. Mahantango Creek.

The surface formed by these red rocks is, as usual, rough, and rather destitute of fertility. This tract lies chiefly in Chapman and Washington townships, Union County.

DIVISION III.

FOURTH SYNCLINAL BELT, OR LEWISTOWN VALLEY AND ITS BRANCHES, FROM THE SUSQUEHANNA SOUTH-WESTWARD.

PRELIMINARY REMARKS.

We proceed now to examine in detail the structure, stratification, and mineral wealth of the next well-marked division of the mountain-chain S.W. of the Susquehanna. This is the long and narrow valley of Lewistown, which, as a natural district, extends from the Susquehanna to Maryland. It is bounded on the N.W. by Jack's Mountain, and beyond the termination of that ridge by Sideling Hill. On the S.E. it is bounded by a succession of chiefly anticlinal mountains of the Levant sandstone, arranged in echelon. These are, in their order, S.W.—the Shade Mountain, ending 1½ miles S.E. of Lewistown; the Blue Ridge, terminating 22 miles further S.W., near the great bend of the Juniata; Blacklog Mountain, ending at Fort Littleton, 19 miles S.W. of the end of the former; and, finally, the ridge bounding the McConnellsburg Cove on the N.W., known as the Little Scrub Ridge and Dividing Mountain, rising near the termination of the last, and ending at the State line. The entire length of the belt is about 107 miles, and its breadth is 4 or 5 miles from the Susquehanna to the end of Jack's Mountain, but from that point to the State line it varies from 7 to 8 miles. The whole tract curves steadily more and more S. as it advances from the Susquehanna.

The general structure of the district is that of a great synclinal trough, diversified, especially between the Susquehanna and the Juniata, by a series of narrow, nearly parallel low ridges, which divide the general valley into several lesser ones, known by distinct appellations. These ridges, and their intermediate valleys, result from systems of parallel anticlinal axes, which have exposed the softer strata—the Surgent slates and Scalent marls especially—to denudation, and thus caused the outcrop of the harder Pre-meridian limestone and Meridian sandstone to project in relief.

Anticlinal Axes.—The distribution or range of each formation being entirely controlled by the course of the anticlinal axes, which are indeed but the flexures of the strata, it is expedient, in the description of every large belt of country, to preface a detailed tracing of the outcrops by a general view of these, and the utility of this plan is conspicuous in the district now before us. I shall commence at the Susquehanna, and enumerate as concisely as possible the several lines of elevation as we advance South-westward.

The *First* anticlinal axis is that of the Shade Mountain, already described. It crosses the river one mile N. of Selinsgrove, being the main axis of the Roaring Creek Valley.

The *Second* axis is that of Longstown Ridge, which crosses the West Branch about 2 miles N.W. of Northumberland, and extends S.W. into Jack's Mountain, becoming the central axis of Kishacoquillas Valley.

Between these two axes, the whole belt at the Susquehanna is merely a single synclinal

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trough, the central portion of which is the Ponent red sandstone, occupying the Blue Hill. The middle of this trough, or the synclinal line, passes about 2½ miles N. of Middleburg.

Near Fort Littleton, the anticlinal axis of Blacklog Valley, passing out through the knob of Blacklog Mountain, crosses the Little Aughwick Creek, and, extending S.W. for 3 or 4 miles, ends in the Cadent and Vergent strata. The great axis of Jack's Mountain, entering the valley at the Three Springs, ranges thence for about 12 miles, terminating in the Ponent rocks S.E. of Sideling Hill, at a point about as far to the S.W. as the end of the Blacklog axis.

From the end of the Blacklog and Jack's Mountain axes, the structure of the whole valley to Maryland is very simple. A single anticlinal axis rises between the terminations of these, and traverses the district S.W. to the Potomac, passing through the middle of Pigeon Cove.

To the S.W. of Orbisonia, the great Aughwick Valley is a simple synclinal basin to its termination; but beyond the ends of Jack's Mountain and Blacklog Mountain axes, the Pigeon Cove axis causes the whole belt to consist of a synclinal tract on the S.E., embracing in its centre the Big Scrub Ridge, and zone of North-west-dipping strata of Cadent, Vergent, and Ponent rocks, on the side next Sideling Hill.

Pigeon Cove is a narrow anticlinal valley lying on the axis. It commences about 8 miles N.E. of the State line, and expands toward the Potomac.

CHAPTER I.

CHARACTER OF THE SEVERAL FORMATIONS IN THE BELT.

THE reader will procure a correct general conception of the character of the strata exposed in the long belt of country under consideration, by carefully inspecting the vertical sections intended as a key to the formations in the vicinity of Catawissa, Danville, Selinsgrove, Newton Hamilton, the S.E. base of Jack's Mountain on the Juniata, and the Potomac at Hancock, and near the mouth of Capon River.

Surgent Series.—A comparison of the sections discloses the fact, that in this belt the whole Surgent series is considerably thicker in the region of the Juniata, than either on the N. Branch or on the Potomac.

The Surgent older and newer slates, with their included iron sandstones, measure at Danville 800 feet, at the Juniata (Jack's Mountain Gap) about 700 feet, and on the Potomac 410 feet. These slates wear their usual characters, being olive, yellowish, and claret-coloured, and somewhat silicious. The iron sandstone is thickest towards the N.E., being 58 feet at Danville,—where, however, it includes much green and yellow sandy slate,—and only 3 or 4 feet on the Potomac, while on the Juniata it is altogether absent. It is only in the Eastern part of the Lewistown Valley—that is to say, chiefly in Union County—that this rock exercises an influence on the shape of the surface, constituting subordinate low ridges at the base and ends of the high mountains of the Levant sandstones. The very lowest layers of the older Surgent slate alternate with the upper beds of the Levant white sandstone; and this alternation, which perhaps properly belongs to the latter, contains a great abundance of the *Arthrophycus Harlani*, the reticulated variety occurring usually in a red or brown stratum.

The *Surgent Ore Shales* are in like manner somewhat thicker at the Juniata than either at Danville or the Potomac, being about 400 feet at the first locality, 230 at the second, and 340 at the third. They retain their usual aspect with remarkable persistency. The upper ore shale is by far the thickest member of the group, and this rather shows a progressive increase from N.E. to S.W. Thus at Danville it is 160 feet, at the Juniata (Jack's Gap) 250 or more, and at the Potomac 295 feet thick. The lower ore-shale declines in that direction, and the ore sandstone slowly augments in thickness. This rock is but 8 feet thick at Danville, 20 feet at Mifflintown (a little too far to the S.E. for comparison), 25 feet at the Juniata, Jack's Mountain, and 30 feet at the Potomac. Being so unerring a guide to the valuable fossiliferous iron-ore, this stratum is particularly worthy of attention. It is in some places of a dirty white, and in others of a yellowish and more ferruginous hue, and is then frequently coarse. Some layers are fine-grained and hard. In some localities it abounds in fossils. The position of this sandstone is readily detected by the ridge which it invariably forms whenever it is 20 or 30 feet thick.

There are two beds of the iron ore, both of them oolitic and fossiliferous, one situated a few feet above, the other at an equally small distance below, the ore sandstone.

At the Danville Narrows both strata may be discerned, but the only productive bed anywhere upon Montour's Ridge is the lower one. This is likewise the bed mined near Lewisburg and at Matilda Furnace (Jack's Gap). On the Potomac the lower bed alone appears. Between the Susquehanna and the Potomac there are few localities where the ore has yet been discovered of a thickness sufficient to render it permanently profitable.

The *Scalent Marls* display a manifest augmentation in thickness as they advance S.W. to the Juniata, and beyond that a more rapid declension to the Potomac, the only exception to this rule appearing to be the variegated marl formation, which is as thick on the Potomac as it is at Mifflintown, or Lewistown, and thicker than at Newton Hamilton, being at the latter place 285 feet, and at the Capon axis 425 feet thick. The Surgent red shale steadily declines toward the S.W. along the belt, being at least 380 feet at Danville, 340 feet at Mifflintown—a little out of the line—250 feet at Newton Hamilton, and only 100 feet thick at the Capon axis on the Potomac. But the most striking variation witnessed in any of the Scalent strata attends the grey marl formation. This, in the vicinity of Lewistown, is at least 500 feet thick; its dimensions on the West Branch of the Susquehanna, near Milton, are still greater, for it there measures more than 1200 feet; near Newton Hamilton it retains the enormous thickness of 945 feet, and yet when it reaches the Potomac it is only 80 feet thick. As by far the most fertile soils of the district under survey are derived from the Scalent marls and limestone, we possess in the foregoing facts of their varying thickness a tolerably fair measure of the relative productiveness of different portions of the great belt of country before us, at least of the tracts occupied by the Surgent and Scalent strata.

The *Scalent Limestone* manifestly increases in thickness as we pass S.W., though it undergoes many fluctuations. It is not easy to reckon on the thickness of this rock at most localities, from the position of its outcrop at the base of the Meridian sandstone ridges; it is, however, obviously thin E. of the Susquehanna, while at Lewistown it has a thickness of several hundred feet. Near Newton Hamilton it measures again only 85 feet, and then expands once more, by the time it reaches the Potomac, to 365 feet. It seems quite probable that, graduating as it does into the grey marls beneath, its thickness on the Potomac is in part caused by the introduction of the limestone layers in the higher portion of the grey marl formation.

Pre-meridian Series.—In the long belt of country before us we discern a general augmentation in the thickness of the chief Pre-meridian formations as we advance S.W., attended, however, by considerable fluctuations. The Pre-meridian limestone seems to undergo a rather steady progressive expansion in that direction. Thus it is about 60 feet in average thickness along Montour's Ridge, while between Lewistown and Newton Hamilton it amounts to about 100 feet, and on the Potomac, above the mouth of Capon River, to 240 feet. East of the Susquehanna the rock is a massive blue fossiliferous limestone containing numerous fossils, and does not admit of subdivision. Near Newton Hamilton it is chiefly massive, and abounds in encrini and corals; but it consists of three measures, there being near the middle of it a bed of shale and grey argillaceous knotty limestone about 7 or 8 feet thick. On the Potomac the whole rock is more argillaceous, and contains occasional thin partings of calcareous shale and many fossils.

The Pre-meridian chert is not constant in its thickness, varying from zero to 30 feet or more. Along Montour's Ridge it is very thin, and sometimes absent altogether: between Adamsburg and Shroyer's it is 30 feet, near Newton Hamilton it is not seen, and on the Potomac we find it from 10 to 20 feet thick. It is very retentive of its characters.

The Meridian Sandy Shale is also a somewhat variable formation. Along the district before us it is thickest towards the N.E., being 30 feet near Danville, 40 or 50 feet near Newton Hamilton, and absent on the Potomac. It seems not to expand N.W. but rather N., and this may explain its absence on the Potomac in a belt so far S.E. as the present one.

The Meridian Sandstone expands and contracts like the rest, but with a general augmentation as we advance S.W. It is scarcely seen at all along Montour's Ridge. Between the Susquehanna and Lewistown it gradually thickens, 70 feet being its thickness at that place. On the Juniata, near Newton Hamilton, it amounts to about 150 feet, and on the Potomac to about 350 feet. This rock changes but little in its characters, the chief modification being in the proportion of calcareous matter.

Cadent and Vergent Series.—The Cadent and Vergent Series is much more complete on the Potomac than on the Susquehanna. In the latter quarter the Cadent newer black slate and Vergent flags appear to be wholly wanting. Only the lower formation, the Cadent older black slate, is continuous throughout the length of the district, the rest having been removed by denuding action from all the central portion of the belt. I shall therefore confine myself in this general account to the Cadent older black slate, which demands a description, as the repository of a useful limestone and a valuable iron-ore.

The Cadent Older Black Slate is manifestly inconstant in its aggregate thickness, though it retains everywhere its aspect and principal subdivisions, if we except the *iron ore.* On the Susquehanna, at Selinsgrove, its total thickness is about 660 feet. It here consists of black fissile pyritous slate, embracing two distinct sets of argillaceous and sandy limestone, alternating with black slate. The lowest of these limestone members commences 45 feet from the bottom, and is nearly 70 feet thick, the limestone layers constituting one-half of the mass. The other set of limestone beds begins 100 feet above the first, and is 50 feet thick in all, though three-fourths of the mass consist of the included black slate. The upper portion, about 400 feet thick, is exclusively pyritous black slate. On the Potomac, 3 miles S.E. of the base of Sideling Hill, the whole formation measures 590 feet. Here ash-coloured slate alternates with the black slate throughout the first 130 feet. We have then about 200 feet of black fissile slate and shale, and above this nearly 30 feet of ashy calcareous shale with layers of impure argillaceous limestone, and above these beds of black fissile slate and shale throughout 240 feet more. In some neighbourhoods E. of Lewistown a coarse silicious limestone, very fossiliferous, occurs, with a purer blue limestone in the lower portion of the black slate. The total thickness of this limestone at Jack's Creek, 10 miles N.E. of Lewistown, is about 30 feet. From Lewistown S.W. the formation usually consists, at its base, of from 10 to 30 feet of black slate, sustaining the argillaceous blue limestone, seldom more than a few feet thick. These are only 10 feet thick at Waynesburg, and still thinner in Bedford County. Above the limestone, at an interval of a few feet—which, however, varies a little—occur the strata of impure carbonate of iron, containing frequently some sulphuret of iron. This ore, when unaffected by the atmosphere, is of a dull greyish lead colour. Above the ore lies a body of black slate, generally several hundred feet thick.

The *Iron Ore* which has been mentioned is regularly stratified, and varies in thickness from 3 or 4 to 10 or 15 feet. Its distance above the Meridian sandstone varies from 50 to 100 feet. Whether its strata exist evenly spread over the region from Lewistown to Maryland, and are to be found wherever the part of the formation they occur in is exposed, or whether it is that only at certain points the slate in that part of the formation is sufficiently mixed with carbonate of iron to form a profitable ore, has not been determined. It is probable that the latter is the case, for the formation is to be seen exposed at points where the ore, if in its usual position, could be observed, and it has not been found.

The ore is often in the form of a ponderous rock, either jointed in square masses of a few inches in size, or it is laminated. It does not efferversce with acid, and when roasted or exposed to the atmosphere, assumes a reddish brown colour, and is strongly attracted by the magnet. It is only in deep excavations that the ore has the characteristics here described, which are those of the original deposit.

Wherever the stratum lies near the surface, atmospheric action has completely changed its aspect, and greatly modified its composition. The ore is there an argillaceous oxide of a hazel-brown colour and smooth texture. That which has resulted from the cubically cleaving strata of the carbonate is in square masses, with large cells affecting the same form. These cells, where the conversion is complete, are empty, and the internal surface of their walls, which are often more than half an inch thick, but generally less, is glazed and irridescent. In other instances the cells are partially filled with pure clay, and sometimes with water; and where the strata have been so protected as to be but little affected by atmospheric agents, a solid bluish carbonate occupies the middle of the lump, surrounded by a thin crust of the brown argillaceous peroxide.

The laminated variety is converted into an ore of corresponding structure.

For a general notice of the several mines of this ore, the reader must consult the general chapter on ores.

Ponent Red Sandstone.—No favourable exhibition of this rock for measurement occurs between Catawissa and the Potomac. At Catawissa the thickness of the formation is 4172 feet, and on the Potomac, S.E. of the base of Sideling Hill, it is about 4500 feet.

A very natural boundary between the Vergent and Ponent rocks is generally discernible in a range of rounded but continuous ridges higher than the neighbouring hills, which mark the outcrop of the Vergent shales, and which bound the Ponent red sandstone.

The central part of this formation is entirely composed of red sandstone and red shales, but the upper part contains grey and buff sandstone in alternation with grey, red, and yellow shales. These latter strata occupy the flanks of the mountain-ridges, capped by the Ponent conglomerate. Having thus described the several formations, we shall in the next place sketch the features of the valley from the Susquehanna to Lewistown.

CHAPTER II.

TOPOGRAPHICAL FEATURES OF THE SEVERAL STRATA.

THE contour of the hills of the Surgent slate is peculiar in this district. In Stone Valley the ore sandstone connected with the fossiliferous ore is usually found in the summits of these hills, but this is not the case with the hills S. of Adamsburg, or those which course round the E. end of the Shade Mountain. These consist of the iron and ore sandstones, and their outline is quite irregular and broken, presenting an appearance which is well expressed by the term ragged. They are found round the ends of Jack's and Shade mountains, being generally three in number, the central and broadest one containing the anticlinal axis of the mountain; and indeed in this light we may consider Longstown Ridge in relation to Jack's Mountain. Two hills of the slate group extend along the Northern base of Shade Mountain, which are not clearly marked from opposite Middleburg to within 2½ miles of Beavertown. Thence for 4 miles W. of Adamsburg they are conspicuous, owing to their complete separation from the mountain, in consequence of the great curvature of the latter, which is not followed by any corresponding bend in the slate hills. From 4 miles W. of Adamsburg, as far as Lewistown, they are not well defined because of their proximity to the mountain, and from being heavily wooded; and for the same reason there are no conspicuous ridges of these strata along the flank of Jack's Mountain.

Topography of the Meridian Strata.—To the N. and S. of the wide belt embraced by the hills of the Cadent, Vergent, and Ponent rocks are limestone ridges, generally covered with chert, and, as we advance toward Lewistown, capped with the Meridian sandstone. As the chert mentioned is found in the upper layers of the Pre-meridian limestone, we can understand why the summits and sides of these ridges should be covered by innumerable fragments of it. These limestone hills run for many miles, occasionally broken by gaps; in some places they have been washed away entirely for several miles.

Through the Dry Valley, in which New Berlin is situated, the Scalent limestone is found, though not constituting a ridge; but as we trace it, towards Centreville, it is seen frequently rising in the form of a hill, and so also through Moser's Valley. About 9 miles W. from Centreville, a second and much higher and more conspicuous ridge of this formation appears, in consequence of the axis of Jack's Mountain, which continues monoclinal in structure to within half a mile of the base of the mountain N. of Muthbough's Tavern. It has been cut down for a short distance—perhaps half a mile—but rises again on Sigler's Farm, and thence continues as a synclinal ridge to Long's, where it finally terminates in a bold knob.

Another ridge of this formation is observed to the S. of the Cadent slate hill which commences on Penn's Creek, one mile from Selinsgrove, though limestone occurs within half a mile of that town. This ridge, with a dip to the N. increasing from 20° on Penn's Creek to 40° and 45° opposite Middleburg, can be traced through the valley of Middle Creek, running N. of Middleburg to within one mile of Beavertown, where another limestone hill rises adjacent to it on the S., having a synclinal structure, which, however, in a distance of a few miles, owing to the dying-out of this axis, unites with the one under consideration. It is then traced N. of Adamsburg, from which point it bears S. 60° W. toward the Shade Mountain, and passes S. of Sigler's, and finally ends in a knob 1½ miles E. of Lewistown. This ridge is in fact, from Adamsburg S.W., the most Southern limestone hill of the whole valley. It is very regular in its course, intersected occasionally by gaps; and being cultivated nearly to the summit, through the valley of Adamsburg, Beavertown, &c., it presents a beautifully scolloped appearance, and is the most prominent feature in the topography of this rich and fertile valley.

In consequence of several axes which traverse this valley, we observe two very singular knobs of limestone between Middleburg and Beavertown, nearer the latter village, which are conspicuous from every part of the valley. They are both of synclinal structure, though not equally symmetrical. The summit of the S. knob (called Traben Kopf, or Grape Knob) is under cultivation, and is broader and more level than the other. These knobs, as we have said, owe their existence to short axes or wrinkles, and opposite them lies the great curvature of the Shade Mountain.

The Pre-meridian Limestone and Meridian Sandstone.—As we approach the Lewistown Turnpike, these ridges are more numerous, and in fact occupy the valley from mountain to mountain, forming, as has been stated, a subdivision of the district into several narrow fertile valleys.

Extending to the Kishacoquillas Creek are four of these limestone hills, which are generally capped with the sandstone for a few miles E. of the turnpike road. The most Northern hill is immediately S. of Rawle's Forge, and constitutes the N. boundary of Dry Valley. It rises boldly on both sides of the creek, having an elevation of at least 200 feet, and on the E. side of the stream the sandstone on the summit forms a synclinal trough. The hill declines in height as we trace it to Kelly's, 3 miles distant, while at the same time its summit increases in breadth, and the sandstone disappears. It finally separates into two ridges, the S. one curving to the S. to join the Toll-gate Ridge, and thus shut in Dry Valley. The N. hill increases in elevation, and sweeps round to the N., and finally ends in a bold high knob before reaching Samuel Sigler's.

N. of this ridge there is another, which rises about 3 miles E. of the turnpike at Long's. It is a synclinal axis: the hill disappears on Jacob Sigler's farm; but another ridge rises again at Sigler's, which contains the S. dips of this synclinal trough.

The second limestone hill extending to the creek lies immediately N. of the Toll-gate Ridge. It is of synclinal structure, but continues only for three-fourths of a mile E. The third ridge is the one which crosses the creek near the Toll-gate, and is composed principally of the Meridian sandstone, with a S. dip of 60°. This hill forms the S. boundary of Dry Valley, after the termination of the second ridge just mentioned. At the creek, and for 2 miles E., it is a conspicuous ridge, with rather steep sides, but as the synclinal axis in the Cadent strata to the S. of it widens, the ground on its S. flank rises until gradually the Cadent slate is on a level with the Meridian sandstone, which at the same time has decreased in thickness. About 4 miles E. of the creek there is a gap, adjacent to which the hill again, owing to denudation, appears distinct, but E. of this the ground becomes once more elevated. As we approach the termination of Dry Valley, however, the hill, consisting there only of limestone, is separated from the Cadent slate to the S., and curves round to join the limestone ridge of the forge. After the junction of these ridges, the high land continues for 1½ miles intersected by deep ravines, which give it the appearance of a succession of knolls.

The fourth ridge crosses the creek, and is continued immediately N. of Lewistown. It is of monoclinal structure, does not extend far either E. or W., and in the former direction gradually blends with a part of another limestone ridge 2½ miles E. of the town.

There is yet another limestone hill to the S.E. of the one last described, which rises 1½ miles E. of Lewistown as a synclinal trough; and after the junction above mentioned, the other fork of this ridge continues with a gentle N. dip on the S. side of the whole valley, past Nixon's Bridge, Sigler's, and the town of Adamsburg.

From these statements it will be evident that the Lewistown Valley presents striking and peculiar features, well worth the painter's study.

Hills of the Cadent and Vergent and Ponent Rocks.—Commencing our description of the topography of these strata at the Susquehanna, the most conspicuous ridges we observe are the Blue Hill, composed of the

Ponent red sandstone, and the slate ridges parallel to it on the N. and S., which constitute the bold bluff on the river, stretching from a few miles above Northumberland to within 1 or 2 miles of Selinsgrove. These hills occupy the central part of the whole valley throughout the district, to within 8 miles of the Lewistown Turnpike, and present topographical features peculiar to the formations. Their outline is regular, with generally smooth summits, and they are frequently intersected by transverse gaps, or rather sloping ravines, of very uniform curvatures. These hills do not accommodate themselves to the axes, or, in other words, it is not possible to solve their geological structure by their configuration.

CHAPTER III.

FLEXURES OR AXES.

HAVING discussed the physical features of the valley as far as Lewistown, we proceed to trace the axes which traverse it, and the various outcrops of the formations, commencing with those on the Susquehanna.

Anticlinal Axis of Longstown Ridge and Jack's Mountain.—The most Northern anticlinal axis runs through Longstown Ridge, and is thence continued into Jack's Mountain. This mountain separates, in a short distance, into two high ridges composed of the Levant white sandstone. Between these, again, rise two other mountains of inferior elevation, composed of the lower rocks of the same formation, and the anticlinal axis takes its course through the valley included between them.

The two N. ridges of the four finally join two corresponding ridges to their N. to constitute a synclinal axis, and by their junction form the N. knob called Stewart's Knob, one of the two which occur in the E. end of the Kishacoquillas Valley. The two S. ridges of Jack's Mountain curve to the S., to unite with two similar ridges of the mountain which ends in Moser's Valley, and by their junction form the S. or Beattie's Knob of Kishacoquillas Valley. The anticlinal axis of which we are speaking continues through a limestone valley included between Stewart's and Beattie's knobs, known as Orr's Valley, and finally dies out a few miles W. of the Bellefont and Lewistown Turnpike.

Synclinal Trough of Blue Hill.—S. of this axis is the great synclinal trough of Lewistown Valley, in the centre of which, near the Susquehanna, lie the Ponent red sandstones. In the main basin there are many beautiful curves in the strata, as may be seen on the Susquehanna in the Blue Hill opposite Northumberland. These, however, cannot be traced for any distance W. of the river, being probably the effects of the dying-out of the axes of the country to the E. of it. The synclinal basin W. of the Ponent red sandstone is occupied by the slate hills of the Cadent and Vergent strata. The dips are not quite equally steep on opposite sides of the synclinal line, which may be placed $2\frac{1}{4}$ miles N. of Middleburg. This trough continues S.W. until it is met by a series of axes, where it is split into various little basins, which will be discussed hereafter.

Anticlinal Axis of Shade Mountain.—The next anticlinal axis on the Susquehanna S. of the Longstown River axis, is rather more than half a mile N. of the town of Selinsgrove in the Pre-meridian limestone. It may be noticed on Penn's Creek, on the road to New Berlin. The S. dip, about 20°, is observable shortly after turning off from the bridge over this creek ; it is soon followed by equally gentle N. dips.

This axis seems to be that of Shade Mountain, formed at the river or on Penn's Creek by the limestone ridge N. of Middleburg, and another limestone ridge near Freeburg on the S. side of the end of Shade Mountain. It curves in its course through the Shade Mountain, though probably in a less degree than the N. ridge of the mountain, if we suppose but one axis to run through this mountain.

The hills of the Surgent slate group are nearly parallel to the mountain opposite Middleburg, and about one-fourth of a mile from its base. Between the same chain of hills opposite Adamsburg and the mountain there is a level space of rather more than 2 miles ; but as the mountain bears to the N., these hills approach its base again, being at the gap, which is 3½ miles from Adamsburg, only half a mile distant. To explain the cause of this remarkable curvature in Shade Mountain is not a very easy matter, but it seems to be connected with subordinate anticlinal flexures in its flank.

It is to be observed that, opposite this remarkable bending of Shade Mountain, there are two anticlinal axes in the valley, which die out at a short distance E. and W. of the bend, and have their maximum intensity opposite the greatest curvature where the knobs of limestone are observed near Beavertown. These secondary axes, which we will presently discuss, are obviously the result of some great irregularity in the force which has elevated the mountain.

In addition to this curve there is another of less amount, where the axes of the S.W. system die out. About 10 miles from Lewistown there are three gaps in the N. ridge of the Shade Mountain, at short and nearly equal distances from each other. Through the middle one there is a road which leads across the mountain to Mifflintown Valley, and it is about this gap that the change of bearing in the mountain occurs. From this gap W., to within 2 or 3 miles of the end of the mountain, the summit bears about S. 60° W., and from the same gap E. N. 65° E., increasing near the gap, from which the great curvature commences, to N. 70° E. Near the W. end of the mountain the bearing is perhaps S. 65° W., owing to the axis of the Blue Ridge. This change of bearing depends simply on the dying out E. and W., near the same point, of two different systems of axes.

AXES OF THE DISTRICT BETWEEN THE SUSQUEHANNA AND LEWISTOWN.

Axis in Moser's Valley.—Moser's Valley lies between the hills of the Cadent and Vergent rocks and Jack's Mountain, and is of greatest width nearly opposite the termination of Jack's Mountain proper. It is, in fact, a continuation of Dry Valley, in which New Berlin is situated, or perhaps it would be more proper to consider the latter as a continuation of the former. There is no axis in Dry Valley, but the dips are generally steep. The Pre-meridian and Meridian rocks traverse the valley in a narrow belt adjacent to the slate hills, and are observed on the N. bank of Penn's Creek at New Burlington with a S. dip of 60°. As we approach the town of Centreville, 3 miles distant, the limestone is noticed occupying a small ridge immediately S. of the village; and as we proceed to Moser's Valley the ridge is washed away for perhaps 2¼ miles, when the road passes over a hill of chert gently elevated. It is again removed by denudation, and the road runs through low ground for 2 miles, when the hill reappears, and continues for 2 miles to Henry Swartz's, and thence, with occasional denudations, for 1½ miles further to within the same distance of John Troxel's, where the hill flattens, and a broad rolling valley succeeds, composed of the Surgent marls, as seen at the Meeting-house. But now we notice a second and much higher hill of limestone, which rises about half a mile W. of Swartz's, the result of the axis of that spur of Jack's Mountain which terminates in Moser's Valley. This second ridge rises abruptly, as if it had at one time extended further to the E., and had been removed by denudation; we may therefore prolong the axis of Jack's Mountain E. of the end of this ridge. The S. limestone ridge is regular and high, and, as far as observation shows, is of monoclinal structure, with a dip to the S.E. opposite to Troxel's. Eleven or twelve miles from Centreville is a gap, where the strata are well exposed, the pale-blue limestone dips 30° S.E. The silicious layers in the upper part of the formation are abundant in organic remains, and interstratified with them are two or three layers of fossiliferous sandstone, from 6 to 10 feet thick, overlaid by silicious limestone. This limestone is of a greyish-blue colour, coarse-grained and silicious, and makes an inferior lime. In the same position it is visible in many parts of the valley, as mentioned in my remarks on the axes of the valleys, crossing the Lewistown Turnpike. The main mass of the Cadent black slate overlies it, and contains beds of a dirty grey calcareous or micaceous sandstone, sometimes quite calcareous, which represent the usual limestone of the black slate (the cement beds). From various circumstances, it seems probable that the N. hill is of synclinal structure, and that the anticlinal axis of Jack's Mountain passes between them. This anticlinal axis could not be observed between the N. limestone ridge and the mountain, and unless we consider it as prolonged between these hills, it is impossible to trace it. The axis, as usual, exhibits gentle dips round the end of the mountain. On John Featherolf's place the Surgent ore sandstone, overlaid by the iron ore, was found showing one gentle dip of 5° to S.E., and between this and the limestone ridges that continue S. of Troxel's, the general dip is not more than 25°. Of the ores we shall speak hereafter. This S. limestone ridge from Troxel's W. is the only one on the N. side of the valley, and is continued N. of Muthbough's to Samuel Sigler's, &c. The anticlinal axis, after the separation of the mountain into four ridges, passes into the valley included between the S. knob and Jack's Mountain, and dies out a few miles E. of the turnpike.

ANTICLINAL AXES, ETC. IN ADAMSBURG VALLEY AND VALLEY OF MIDDLE CREEK.

Anticlinal Axis S. of Middleburg.—Of these there are two; the first is the one immediately S. of Middleburg, and to it we shall now direct our attention. It is not prolonged E. to the Susquehanna, and no traces of it are to be found between the Pre-meridian limestone ridge on the N. and the Surgent slate hills surrounding Shade Mountain, on a section made 4 or 5 miles E. of Middleburg at Reed's Tavern.

The distance between the limestone ridge and the slate hills is there about half a mile, and in a gap of the former is a quarry of excellent blue limestone, fine-grained and fossiliferous, occurring in thick massive layers with interstratified belts of black calcareous shale, or thin limestone bands, dipping 45° and 50° to N. 10° W. At Middle Creek, 120 yards from the quarry, the argillaceous layers of the Scalent marls are found with the same dips, and the Surgent red shale occurs at the tavern, and thence to the slate hills there are no evidences of a contrary inclination of the strata. The dip above given decreases very much as we approach these hills, in which the Surgent slates are generally observed at an angle of 10° N. About 2½ miles from Middleburg is a cross road over these slate hills to Freeburg, on which the limestone beds of the Scalent marls are found purer in quality than in any other part of the Lewistown Valley. The dip is only 7° N., and some layers of the limestone are very hard and silicious. This dip increases to 32° on the main road, in the red sandstone of the same formation.

The anticlinal axis is first observed in a middle creek about 1½ or 2 miles from the town, where the N. dip is 30°; and from the remarks which have been made, it will appear that the axis does not extend much further towards the Susquehanna. About one mile from the town, on another cross road leading to Freeburg, a synclinal axis is noticed in the red shale, having very gentle dips, but as the ground between this exposure and the limestone ridge is low, the position of the anticlinal axis is uncertain. It is found in a hill immediately behind Middleburg, or rather W. of S. of the town, in the greenish argillaceous shales of the Scalent marl group, exposed in a section of dips obtained on the bank of Middle Creek north from John Bowersock's, of which we shall speak shortly. The axis can thence be traced between the N. of the two limestone knolls and the hill N. of Middleburg; thence between the two limestone hills which are here noticed as lying N. of Beaverstown, and finally it dies out a short distance from Adamsburg, when these two hills unite and form one. Opposite to the N. limestone knoll, the strata in the N. limestone hill dip 50° N.W., the strike being here nearly 20° different from that near Middleburg; and we find that as we proceed from this point E., this N. limestone ridge bears constantly towards the E., until finally, near the Susquehanna, it is almost E. and W.

There occurs S. of the anticlinal axis just traced, a synclinal axis in the N. knoll of limestone, which passes into the first limestone ridge N. of Beavertown, and terminates or rises one mile E. of the town; and a second anticlinal axis between the knolls and another synclinal flexure in the Southern knoll, which is called the *Grape Knob.* We may discuss these together. See the following cut, Fig. 76, where *a* is the N. knoll, and *c* the S. one; the arrow-heads showing the several axes.

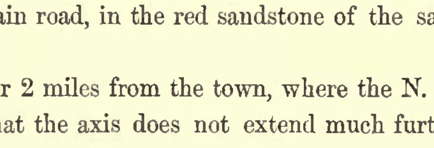


Fig. 76.—Knolls of Pre-meridian limestone near Beavertown.

As was stated, the synclinal axis of the N. knob of limestone passes into the first ridge N. of Beavertown. This would not at first appear to be the fact, judging solely by the topography, as the knob does not seem to be in continuation of the ridge; but when we examine the strata which lie between, we find evidences of contortion, change of bearing, &c., which are accounted for by the fact that the synclinal axis curves in its course from the knob in order to pass into the ridge; and this curving, attended with confusion in the dip, is evidently connected with the great curvature of the Shade Mountain to the S., and shows to what disturbing forces the strata of this valley have been subjected. On the N. of the knob, the dip, in one exposure, is 25° to S. 10° E. On the top of the knob, at the S. edge of the summit, the dip is 60° N. 25° W., which, however, decreases as we descend the knob on the S. side, becoming 30°, and at the W. end, on the bank of Middle Creek, 10° and 15° to N. 5° E. In the other, or S. knob, the synclinal axis exhibits gentle dips of 10° or 15°, with a strike N. 60° E.; and as both knobs run N. 70° or 80° E., it is evident that this change of strike must be accompanied by great confusion. This is very apparent near Solomon Close's, about 2 or 2½ miles from Beavertown, where the strata bear to every point of the compass, generally, however, dipping to the N. even on the N. of the N. synclinal knob, where we should suppose the dip would be S. if no irregularity occurred. This synclinal axis, of course, ceases W., with the anticlinal on the N. of it. Of its extension towards Middleburg we shall speak again.

The second or S. synclinal axis is found in the Grape Knob; the dips on the summit are much less than those in the other knob, being only 15°, but steeper on the S. side than on the N., which is the case with the strata on the N. knob. At the W. end of the knob on Jacob Sigler's farm, the dip is 25° to N. 25° W., but the strata are in some degree contorted, Layers of good blue Scalent limestone occur, some of them rather silicious; they contain a few minute fossils. Calcareous spar in some quantity is found in beautiful crystals. The anticlinal axis included between the knobs cannot be traced W. with any accuracy, but it passes perhaps through Beavertown, and is found between a quarter and a half of a mile S. of Adamsburg, where the dips are gentle; but W. of this it can scarcely be said to exist. In consequence of the dying-out of these several axes, the limestone ridge in the N. of Adamsburg bears towards the Shade Mountain, ranging S. 60° W., and the valley may be said to close.

Let us now trace these axes E. Owing to extensive denudation, the strata have been swept away from these limestone knobs nearly to Adamsburg, and the level ground is generally covered with fragments of the Levant white sandstone from the mountain. We are therefore not able to obtain any exposures exhibiting the structure of the valley for a considerable distance. From Bowersock's on Middle Creek north a section of the strata exhibits in the contortions the effects of the axes under discussion; the dip, however, is generally to the S., though changing rapidly in steepness. The strata in some parts of the exposures are the Surgent flaggy limestone, though the chief portion belongs to the Scalent marl group.

Along this section there are many changes in the steepness of the dip, though the direction is generally to the S. from the axis which passes through Middleburg; but as we found a synclinal axis well developed in the Surgent red shale one mile E. of the town, and as the distance between the limestone on the N. and the slate hills on the S. is so considerable, we can with propriety mark the axes as extending E. beyond Middleburg, at least the synclinal axis of the N. knob. The strata from the town to the mountain must evidently have a gentle dip, or else a succession of undulations. The dip in the hills of Surgent slate adjacent to the mountain is rather steep. The Surgent ore sandstone is found at the N. foot of the hill, having an exposed thickness of 15 feet, and a dip 50° to N. 10° W., and the iron sandstone and yellow slates on the S. side of the summit dip 30° to N. 15° W.

We have thus traced all the axes of the Lewistown Valley which appear on the Susquehanna, as well as the secondary axes, which may properly be said to belong to an Eastern system. From this Western termination the geological structure of the valley is exceedingly simple, one synclinal axis passing through the central part of the valley in the Cadent rocks, until within about 10 miles of the Lewistown turnpike, when numerous axes appear, belonging to what we may call the S.W. system. But in order to exhibit these latter more clearly, we shall describe a section on the Kishacoquillas Creek, and then trace each axis to its E. termination.

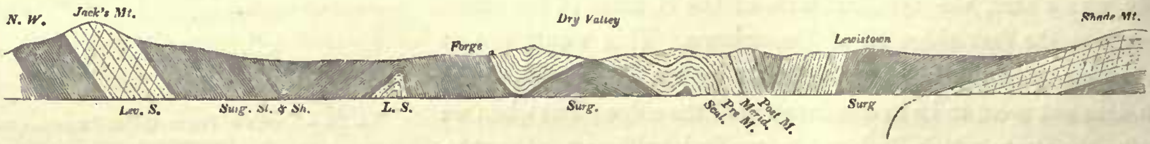


FIG. 77.—Section across the Lewistown Valley near Kishacoquillas Creek.

On this section there are four anticlinal and five synclinal flexures, lying chiefly in the Surgent, Pre-meridian, and Meridian strata, with the exception of one trough which includes the Cadent rocks. The fourth anticlinal and fifth synclinal flexures are not shown in the cut.

The *First Anticlinal Axis* occurs half a mile S. of the synclinal line, or about one-third of a mile N. of the forge in the Surgent red shales. The S. dips of the axis exhibit some irregularity as we approach the forge, averaging, perhaps, 30° S.; and as we trace them along the creek opposite the next synclinal axis in the limestone ridge, the dips decrease to 10° S.

The *Second Anticlinal Axis* occurs in the bold limestone hill immediately S. of the forge in the Meridian sandstone. On this ridge the dips are rather steep—more inclined, however, on the S. side of the hill.

The *Second Anticlinal Axis* is that of Dry Valley, but the strata along the creek, embracing this anticlinal and the preceding synclinal flexures, exhibit much irregularity and various contortions, which extend to the *third synclinal* axis. This lies in a hill of limestone, which, on the E. side of the creek, is only half or three-fourths of a mile in length, but extends W. many miles, and is there capped by the overlying Meridian sandstone.

The *Third Anticlinal Axis* is found between this hill and the one which we have designated as the Toll-gate Ridge, in which the dips, as seen on the creek, are very steep—60° S.

The *Fourth Synclinal Axis* succeeds, and contains a thin belt of the Cadent black slate, with layers of dark argillaceous sandstone. The N. dips of this axis are also very steep; the Scalent and Pre-meridian limestone in the ridge which was immediately N. of Lewiston dipping at an angle of 70°. Several rolls occur in the strata on the creek, and the *fourth anticlinal axis* is found about 400 yards N. of the ridge which crosses Kishacoquillas Creek on the S. road, and passes about 300 yards S. of Lewistown. A few rolls occur S.E. of this axis again, and the dip finally becomes N. at first 50°, then 30°, and at last 20° N., constituting the *fifth synclinal axis* of our section.

First Synclinal Trough.—Let us now trace these axes, and the belts of strata connected with them, separately, commencing with the N. ones. This axis, we have said, occurs in the calcareous Surgent marls, about half a mile from the base of Jack's Mountain, embraced by steep dips; as we trace it E. these decrease much in steepness, especially the S. dip, and consequently the axis recedes much further from the mountain. About 3 miles from the turnpike, at Long's, a ridge of Scalent limestone rises, containing this synclinal axis, with a dip of 20° N. This hill continues only for a short distance, subsiding on Jacob Sigler's farm; but at Samuel Sigler's a hill is observed, which contains the S. dips of this axis, 50° S.E. in the same limestone, and on the road we see a few layers of the Meridian sandstone. A short distance S. of Long's house this sandstone is seen dipping 10° N., and about half a mile E. of Sigler's the Cadent black slate occurs, rising in this synclinal axis, which is continued in the black slate for perhaps one mile E. of Muthbough's Tavern.

First Anticlinal Axis.—This axis lies in the red shale, one-third of a mile N. of the forge. As we trace it E., it enters the Scalent marls, as at Kelly's, where a S. dip of 45° exists. The axis then ranges between the limestone ridge, which has just been noticed, and the Forge Ridge; but before following it further, it is expedient to trace this ridge E. from the creek.

Limestone Ridge, Second Synclinal Trough.—This hill rises from the creek to a considerable elevation, and is capped with the Meridian sandstone in a synclinal flexure with steep dips. As we trace it E. to Kelly's, it falls in height, its summit growing wider, and the Meridian sandstone being removed by denudation opposite to Kelly's. Two miles and a half E. of the forge there occurs a gap, on both sides of which the ridge is of an inferior height, and on the E. side of this gap the ridge separates into two crests, the synclinal axis passing into the little valley between them, and holding the Cadent black slate $1\frac{1}{2}$ miles E. of this gap. How far this axis continues it is impossible to say, but it may be traced as far as a line drawn from Muthbough's transversely to the course of the strata; but of this we shall speak again, after having traced the other axes of the section.

First Anticlinal Axis.—The more Northern of the two hills into which the Forge Ridge divides, rises steadily in height, having the Meridian sandstone in its S. brow. It also curves to the N., as if to unite with the portion of the synclinal hill which rises at Long's, the two embracing between them the anticlinal axis noticed half a mile N. of the forge. This hill at Long's, however, has been degraded by erosive action of water; but there appears, a short distance N. of the road, a small eminence of the Meridian sandstone, which we may consider a link proving their original junction, while the N. fork of the Forge Ridge curves to the N., and finally terminates in a high and conspicuous knob near Sigler's, through which the first anticlinal axis passes. See Fig. 78.

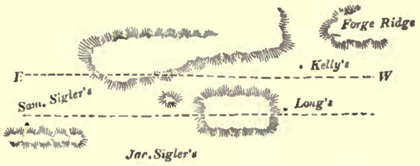


Fig. 78.—Topography of Forge Ridge.

This axis extends in the Pre-meridian limestone about half a mile E. of Sigler's, thence passes into the Meridian sandstone, and finally into the Cadent black slate; but the same uncertainty before mentioned with regard to the other axes prevails in respect to its extension E.

It is difficult to determine the position of this axis on the Kishacoquillas Creek, as the strata there exhibit several changes of dip both in steepness and direction. The rocks are the Surgent marls, embracing the ash-coloured argillaceous calcareous beds.

The axis is prolonged in the marls for 2¾ or 3 miles, where the limestone occupies the valley now lying between the Forge and Toll-gate ridges.

The valley terminates about 5¼ miles E. of the creek in an oval form, the dips of the limestone averaging perhaps 15° to the N., N.E., E., S., and S.E. It is closed, as has been stated, by the junction of the S. fork of the Forge Ridge and the Toll-gate Ridge, which latter is throughout of monoclinal structure. In a quarry in the hill, on the N. of the valley near its termination, the dip is 10° to N. 10° E. This quarry exhibits three qualities of limestone. A bluish black limestone forms the lowest bed, above this a greyish white limestone, overlaid again by a beautiful white variety, which is perhaps the best. Round the end of the valley the limestone is generally of good quality, of a blue colour, and associated with the white, fetid, encrinitic limestone, which forms the upper portion of the Pre-meridian limestone formation. Beyond the junction of these ridges the limestone extends E. in high rolling fields, intersected by deep transverse ravines. Its E. limit is about 200 or 300 yards E. of Sterrett's house, whence the axis passes into the Meridian sandstone, and finally into the Cadent black slate.

Third Synclinal and Third Anticlinal Flexures.—These flexures continue for a short distance E. of the creek in Dry Valley; the trough occurs in a hill of limestone, which, on the W. side of the turnpike, is capped by the Meridian sandstone. The anticlinal axis runs through the little valley between this hill and the Toll-gate Ridge, in which latter the S. dip of the axis is 60°, and though it soon ceases E., it runs for many miles in the opposite direction.

Fourth Synclinal Axis.—This trough is formed by the oppositely-dipping strata of the Toll-gate Ridge and the hill of limestone immediately N. of Lewistown. A narrow belt of Cadent black slate is observed on the bank of the creek, marking the middle of the trough. The dips on the turnpike are very steep, 60° to 70° S., and 70° N. As we trace the basin E. the dips decrease. An exposure on the Toll-gate Ridge, on the road crossing to Dry Valley, shows the inclination to be 45° to S. 20° E. The extension of the axis is uncertain, but it is probably prolonged as far as the anticlinal axis of Dry Valley.

Fourth Anticlinal and Fifth Synclinal.—The strata exposed on the Kishacoquillas Creek, half a mile E. of Lewistown, displays several contortions, but the anticlinal axis may be placed about 400 yards N. of the bridge which crosses the creek, and about 300 yards S. of Lewistown. The fifth synclinal basin lies S. of this, and exhibits several contortions.

About 350 yards below the anticlinal axis there is a roll or contortion, and another, 50 yards S. of that, then a regular synclinal axis, with dips decreasing from 55° to 20° and 15°, and this last dip continues to the Shade Mountain. The undulations within this basin are seen opposite Lewistown, where the variegated and grey marls are finely exposed in a series of cuts on the Pennsylvania Railroad. A great thickness of these may be seen dipping towards the N.W., also a flexure in its steep S.E. dip, which is very nearly vertical. The N.W. dip is from 30° to 45°.

There is a smaller flexure of the same character further N. There is but little true transverse cleavage except near these anticlinals, where, as usual, it is fan-shaped, or radiating from the axis plane, further off from which it is parallel with the axis plane, or in this instance steeply to the N.W. This parallelism of the cleavage to the axis plane, even where this latter dips to an unusual quarter, is extremely interesting.

In the centre of one of these anticlinal flexures we see the innermost beds crumpled, to conform themselves to compression within the concave curve. (See the following Sections.)

About $1\frac{1}{2}$ miles E. of Lewistown a hill of limestone rises, lying in the fifth synclinal trough, and about 3 miles from the town the road passes over high ascending ground, which marks the gradual junction of the limestone ridge N. of Lewistown with a part of the synclinal hill mentioned ; and after crossing this high ground the black slate is soon observed, whilst on the S. the limestone hill ranges on, containing the N. dips of the fifth synclinal axis. This N. dip is gentle, as observed in the several gaps intersecting this ridge, which is the most Southern limestone hill of the whole valley, and is the one extending N. of Adamsburg. These axes cannot be traced with accuracy far E. They pass into the black slate, the topography of which is generally so inexpressive as to afford no clue to the geological structure. In a section opposite Rough's Mill, $4\frac{1}{2}$ miles from Lewistown Mill, there appear several hills of the Cadent black slate, included between the S. limestone ridge and the Toll-gate Ridge, but the dips could not be ascertained. Near the foot of the mountain, about quarter of a mile S. of Simon Gro's house, the Surgent ore sandstone occurs, dipping 45° to N. 30° W., the slates which undulate with this rock gradually declining in dip to 35°, but as we proceed to the S. limestone ridge, which is three-quarters of a mile N. of his house, the dips decrease greatly in amount, being only 10° for a considerable distance; and as we enter the gap to Roush's, the limestone appears dipping 15° N., which increases to 20° and 30°: there is also a change of dip to S. 30° for a short distance, when the former dip is resumed, though at a less angle. The limestone is here well exposed. There is probably no true synclinal axis in this hill. Proceeding N., the next hill is composed of the Cadent black slate, with its calcareous belts of little value, and a bluish sandstone. The next hill is of the same formation, and embraces the same strata. We then pass to the limestone ridge S. of Dry Valley, which is here scarcely distinct from the Cadent slate ridge last mentioned. From this section it is probable that the anticlinal axis immediately S. of Lewistown has drooped away, and that there remains only one synclinal axis included between the two limestone ridges. The dips in the S. limestone ridge become more gentle as we trace it to Bridges', about 8 miles from Lewistown. His house is near the limit of the Pre-meridian limestone and Meridian sandstone, about one-fourth of a mile N. of the summit of the limestone ridge, which is here of considerable elevation. The silicious limestone which occurs in the upper part of the Pre-meridian limestone is found in a field to the W. of Bridges' house, constituting a series of isolated knobs in a line with the strike of the strata. These are, in some instances, nearly 20 feet high, and present almost perpendicular walls. The rock is very silicious, and abounds in fossils ; it has been used, however, for making lime. The dip is 10° to 15° N. The ridge terminates abruptly $1\frac{1}{4}$ miles N. of John Sigler's, but rises again S. of his house, though with inferior height, appearing as a small hill, which increases in elevation E., a high abrupt knob terminating the ridge. The limestone here is well exposed, exhibiting blue limestone of a good quality overlaid by the arenaceous beds. The dip is 30° N. 30° W ; and this may be taken as the uniform dip in this ridge as far as Adamsburg.

General Synclinal Structure of the Valley.—Having thus discussed all the axes of the valley as far W. as Lewistown, let us investigate the manner in which these axes, by successively subsiding, form the one great synclinal trough. Between the limestone ridges near their Eastern terminations several hills of the Cadent black slate appear and unite with each other, though confusedly, in obedience to the several axes which traverse them ; but it would not seem that any one of the synclinal axes above traced is prolonged as the main synclinal line of the valley. In a section drawn from John Sigler's past Sterrett's, there are found two anticlinal axes, viz. the axis of Dry Valley, and that of the knob terminating near Samuel Sigler's. It would appear that the N. anticlinal axis dies out first.

FIG. 79.—Anticlinal Flexure in Dry Valley.

In the next place, the S. anticlinal axis, or the axis of Dry Valley, dies out, and we then have but one synclinal axis ; and hence the general synclinal axis of Lewistown Valley is prolonged into the anticlinal axis of Dry Valley.

CHAPTER IV.

IRON ORES.

Of the Iron Ores in the Meridian Sandstone and Cadent Black Slate.—Beds of iron ore have been opened W. of Lewistown, near the junction of these strata, but none have ever been found of any value throughout the district. As far E. as the Susquehanna the Meridian sandstone decreases in thickness, and appears to grow less ferruginous as we trace it. Some excavations were once made on the ridge running S. of Dry Valley, in the section opposite Roush's Mill, and the ore was used in the Old Furnace, which formerly stood on the present site of Roush's Forge ; but the supply was not abundant, nor the ore rich. Not far from Bridges' house there occurs a sulphureted hydrogen spring in the Cadent black slate, the smell of which is perceptible for a distance of 100 yards.

Iron Ore in the Scalent and Pre-meridian Limestones.—The limestone ridges of the valley are frequently covered with fragments of ore on the limestone hill N. of Adamsburg, as well as on the S. isolated limestone knoll 2 or 3 miles from Beavertown ; but in every case there is an absence of sufficient evidence in the character of the soil and in the contour of the ground of the existence of valuable deposits of this mineral.

IRON ORES IN THE SURGENT ROCKS.

Lower Ore.—The two chief iron-ores of the Surgent series both occur in the region reviewed. One—the block ore—is in the buff and olive slates, or Surgent older ore-slates in the iron sandstone, and usually outcrops on the flanks of the mountains of the Levant sandstones. It is of a light brown colour, sometimes of a slaty structure, and is generally too impure for use in the furnace by itself. The other—the fossiliferous ore—of the Surgent calcareous shales, adjoins the ore sandstone, and outcrops in a ridge at the foot of the mountains.

Block Ore.—This ore is abundant near the base of Shade Mountain. Within the last few years it has been mined in the neighbourhood of Middleburg, 1¼ miles E. of Beaver Furnace. The bed is 7 feet thick, and the quality of the ore is unusually good. Its outcrop is 100 yards from that of the fossiliferous ore, and it dips 30° N. It is underlaid by the ore sandstone, red and grey, in a bed 30 feet thick. Beneath this sandstone, at a distance across the outcrop of the strata of 40 yards, lies another ore-bed, 12 inches thick, full of joints of encrini, and called from this the Bird-eye Ore. Other localities show the presence of the block ore in numerous scattered fragments.

Fossiliferous Ore.—This ore, which is worked so extensively E. of the Susquehanna at Danville, Bloomsburg, and elsewhere, appears to possess but little value throughout the Eastern division of the Lewistown Valley. It seems to consist of small granules of quartz, cemented by yellowish - brown oxide of iron, and where the specimens have been long exposed to the atmosphere, the silicious grains are distinctly observed. It generally weathers into rounded fragments, destitute of the sharp edges indicative of the purer varieties, but occasionally has a square fracture breaking into masses of that shape, as at Middlesworth's Mill.

The ore ranges in two belts, one near the base of the Shade, and the other along that of Jack's Mountain. On Kishacoquillas Creek, in the gap of Jack's Mountain, the ore sandstone projects boldly on the E. bank of the stream. Owing to the character of the country along the foot of this mountain, it is difficult to trace the ore until the formation enters Moser's Valley. Here it is found on several farms exhibiting the characters already described.

Another outcrop of the ore-imbedding strata ranges along the base of Shade Mountain, but though the ore is found in many places W. of Lewistown, it was nowhere seen further to the E. until within one mile of Beavertown. It should, however, be found S. of Simon Gro's, overlying the encrinal ore sandstone, which is there of considerable thickness. At Middlesworth's Mill we have a beautiful section of the rock adjacent to the ore, and also of the Surgent marls. This mill is about one mile W. from Beavertown, and stands upon a small stream half a mile S. of the main road to that village. The lowest rock exposed is the ore sandstone, of a greenish white colour, very hard, and containing fossils. The dip is 30° N. Over the sandstone lies the ore in a seam 8 inches thick. It is generally silicious, breaks into square masses, and exhibits the grey micaceous oxide of iron scattered through it. A thin seam of shale apparently divides it into two seams, the upper one being 4 inches thick, and apparently of the best quality.

There is no difficulty in tracing the ore along the N. base of the slate hills S. of Adamsburg and Beavertown. It is found near Ripton's house, 1½ miles E. of Beavertown, where the ore sandstone occurs dipping 40° N. It is also seen at the N. base of the hills, 1½ miles E. of Middleburg. Here the sandstone is observed in place with a thickness of about 15 feet, and a dip of 50° N. 10° W. Upon it there lies a thin seam of the ore, of a very silicious composition.

So far as these observations show, the fossiliferous ore of the region generally seems to be of little value, though there are no doubt localities at which it will be found with a thickness and richness which may make the mining and smelting of it permanently profitable. One of these would appear to be the vicinity of Beaver Furnace, 2½ miles W. of Middleburg. At the spot where the ore is mined, 2½ miles W. of the Furnace, there are two beds of it about 30 feet apart, both of them varying in thickness from 8 to 12 inches. A bed of sandstone overlies each seam of ore; that reposing on the upper seam is rough, and 20 feet thick.

CHAPTER V.

FOURTH SYNCLINAL BELT—FROM LEWISTOWN TO THE MARYLAND LINE.

Having thus presented in sufficient detail the geology of the Eastern division of the Lewistown Valley, I shall next enter upon a description of the S.W. portion embraced between Lewistown and the Maryland State Line.

From Lewistown S.W. for nearly 40 miles, the valley, which is here between 4 and 5 miles wide, curves steadily S., the strike of the strata changing from S. 50° W. at Lewistown, to S. 30° W. at Shirleysburg. The numerous parallel anticlinal flexures, by bringing successive belts of the Surgent, Pre-meridian, Meridian, and Cadent Black Slate to the surface, give great variety and considerable fertility to this division of the district.

From the Juniata S.W. the wider central tract of the general valley is called the Great Aughwick Valley, being traversed by the Great Aughwick Creek. Germany Valley, at the end of Blue Ridge, is separated from it on the S.E. by Owen's and Prater's ridges, and from Hill Valley on the N.W. by Chestnut Ridge. Beyond Shirleysburg S.W. the whole area between Jack's Mountain and Blacklog Mountain is called Great Aughwick Valley. Hare's Valley, lying between Jack's Mountain and Sideling Hill, unites with the Aughwick Valley by the ceasing of the intervening Jack's Mountain, and there is thence to Maryland one wide valley 35 miles in length, bounded on the N.W. by Sideling Hill, and on the S.E. by Blacklog Mountain and the Little Scrub Ridge and its prolongation, Dividing Mountain. Pigeon Cove is the only part of this that receives any special name.

RANGE OF THE SEVERAL FORMATIONS IN THE LEWISTOWN VALLEY, FROM LEWISTOWN TO MARYLAND.

Surgent Series.—Surgent Slates and Marls North-west of Lewistown, and along the Flank and Base of Jack's Mountain to its Termination.—This formation at Brown's Gap, where crossed by Kishacoquillas Creek, is nearly 1¾ miles wide, extending about half-way up the flank of the mountain, and forming the N.E. side of Furguson's Valley. It is traversed by the first anticlinal axis, the South-east-dipping strata of which pass under the Scalent limestone, dipping the same way along the middle of Ferguson's Valley. N.W. of this axis the Surgent strata lie in a synclinal trough, running along the base of the mountain. Thus we have the N.E. side of Ferguson's Valley and the flank of the mountain occupied for 7 or 8 miles S.W. by a belt of these rocks, having three dips. This belt becomes narrower also in that direction, by the approach of the first anticlinal axis to the base of the mountain. Between 7 and 8 miles from the N.E. end of the valley, the overlying Pre-meridian limestone begins to lie in the trough between the first axis and the mountain, and thus divides the Surgent marl into two belts. That on the S.E. side, having an anticlinal structure, gradually tapers to a point at a distance of 2 or 3 miles further on, where the Scalent limestone rises and saddles the axis; whilst that on the N.W. side occupies, with a S.E. dip of 45°, the flank and base of the mountain. It continues high up on the mountain for 8 or 10 miles; but as we go S.W. it gradually leaves its side in obedience to gentler dips, and forms at length the N.W. side of the Long Hollow, and near Drake's Narrows lies entirely at its base, dipping S.E. 22°, forming a belt there half a mile broad.

When traced across the Juniata, its strata, still dipping S.E. 25°, form the N.W. side of Hill Valley, which lies between Jack's Mountain and Chestnut Ridge, and hold the same situation at the base of the mountain for 15 miles, until this terminates at the Three Springs: here they fold round its end and over the axis to meet the belt belonging to Hare's Valley.

Fossiliferous Ore and Hard Belt.—The first anticlinal axis in Ferguson's Valley lifts the ore sandstone in a ridge extending for 5 or 6 miles, and at some distance from the base of Jack's Mountain. On the upper layer of the sandstone the fossiliferous ore reposes; and we therefore find it on both flanks of the ridge; its S.E. dip 30°, and its N.W. dip 80°. (See Section.)

The ore has been mined only in one place, on the farm of Mr McKey, and used at Hope Furnace. It is of the soft variety, only that near the outcrop being dug, and is about a foot thick, but with intervening laminæ of slate. We found the ore at several points, through a knowledge of its position, near the upper layer of sandstone. The North-west-dipping stratum of ore will probably be found to be of little value, its steepness preventing that copious infiltration which is essential to the existence of the soft ore. It ranges for 5 or 6 miles.

The outcrop of the Surgent rocks on the flank of Jack's Mountain also develops the ore with a S.E. dip. From Brown's Gap S.W. for a number of miles, it lies rather high up on the flank of the mountain, and is covered by loose masses of the Levant white sandstone. The hard belt, however, in many situations forms a distinct ledge or rise, indicating the position of the ore. This ore has been nowhere opened upon this belt between Brown's Gap and Drake's Narrows, except at Matilda Furnace, where, the formation beginning at the base of the mountain, the sandstone produces a very distinct sharp-backed ridge, on the S.E. flank of which the ore is traceable for several miles. Its character at Matilda Furnace will be given in the Section on Ores.

Across the river in Hill Valley a distinct ridge of the ore sandstone is discernible for 6 or 7 miles, but the ore itself has not yet been opened, although it will probably be found there in as thick a stratum as at Matilda Furnace. No surface specimens of the ore were observed further to the S.W., nor does the hard sandstone in that direction any longer form a ridge, having been levelled and its outcrop covered with debris by the currents that swept over Jack's Mountain from the N.W. At the end of Jack's Mountain, and S.W. of the main branch of the Three Spring Creek, we perceive a tract of high ground containing the hard ore sandstone exposed upon the creek; but specimens of ore do not occur in its neighbourhood. Not far distant from this, however, in Hare's Valley, specimens were found by the Geological Survey, so that the ore probably exists thus far to the S.W.

Surgent Slates and Scalent Marls South-east of Lewistown and Waynesburg, along the Blue Ridge.—Lewistown stands upon the Scalent marls and limestone, which dip N.W. Between the town and the Blue Ridge the Scalent marls and Surgent slates occupy the entire space, being traversed by the fifth and sixth axes. This belt is at least $1\frac{3}{4}$ miles wide, and continues with that width to form the larger portion of the valley for 10 or 11 miles S.W. The fourth anticlinal axis elevates a narrow belt of Surgent marls along several miles of its course, from a point $1\frac{1}{2}$ miles S.W. of Stroud's Mill, to where it disappears beneath the Scalent limestone three-fourths of a mile S.W. of Waynesburg, on the S.E. side of which it passes in its course; the village itself standing on the North-west-dipping alternations of the Scalent limestone. The South-east-dipping strata of the fourth axis, in this part of its course, are not more than 200 or 300 yards wide, from which circumstance it happens that, almost as soon as the marls rise, the limestone ceases to lie in the synclinal trough S.E. of them. (See the Map and Sections.)

From Waynesburg south-east to Blue Ridge, the Scalent and Surgent marls and slates, traversed by three anticlinal axes, occupy the whole surface, with the exception of a narrow strip of Scalent limestone between the fifth and sixth axes.

From Lewistown south-east, and extending some distance up the flank of the Blue Ridge, there is a belt of Surgent slates and Scalent marls, with two anticlinal axes, its N.W. limit passing by Lewistown and Stroud's Mill, S.E. of the turnpike. Further on to the S.W., the fourth axis lifting the same rocks more to the N.W., as before described, their N. limit passes through Waynesburg.

The fifth axis, running from Lewistown south-west, develops these same rocks along its line with gentle dips, and in a belt $1\frac{1}{4}$ miles broad. From a point S.E. of Stroud's Mill to a point opposite Waynesburg, the position of the axis is indicated by a considerable ridge, formed of the ore sandstone, with its fossiliferous ore. S.E. of Waynesburg, this belt of Surgent marls and slates is separated from that lying nearer to Blue Ridge by the occurrence of the Scalent limestone, in the synclinal trough between it and the sixth axis, or that continued from Shade Mountain.

About 3 miles S.W. of Waynesburg, the Scalent marls exposed by the fifth axis disappear under the Scalent and Pre-meridian limestones, the latter formation forming a high broad ridge. That part of the general belt of Surgent strata formed by the sixth anticlinal axis, and the North-west-dipping strata flanking Blue Ridge being separated from the portion N.W. of it by the strip of limestone opposite Waynesburg, just mentioned, extends for several miles with three dips, after which the Scalent limestone occupies the synclinal basin between the sixth anticlinal axis and the Blue Ridge, and divides it into two belts. Of these, the N.W. one (the anticlinal), formed of strata dipping about 60° from the axis in opposite directions, runs along the S.E. side of the Juniata River for 3 or 4 miles. It is narrow, and, gradually tapering to a point, ends N.W. of Galloway's Gap in Blue Ridge, and disappears under the Scalent limestone. The other belt, the strata of which dip 50° or 60° N.W., stretches along the base and flank of Blue Ridge, ascending about one-fourth of its height. Toward the termination of Blue Ridge, the Surgent slates and marls lie entirely at its base. Having arrived at the end of the mountain, they fold round, being continuous with the same formation on the S.E. side of Blue Ridge, in Negro Valley. Where the belt folds over the anticlinal axis of Blue Ridge, it spreads out so as to form a considerable portion of Germany Valley, towards the S.W. end of which it terminates in a point caused by the overarching of the limestones.

Fossiliferous Ore and Ore Sandstone.—The ridge formed of the ore sandstone by the fifth axis is probably 150 feet high, wide and barren. The fossiliferous ore lies on both sides folding over its extremities. The ore reposes on the upper layer of sandstone, with olive-coloured shales above it. It has been opened on both sides, and used at the Hope Furnace. It is not more than 4 or 5 inches thick, and in some places divided into two thin strata by an intervening slate. Still, however, it is of considerable value, for in many places the soft shales have been so much denuded that the ore is near the surface, and in that position is of the most valuable variety, being soft and porous. It dips from 10° to 20°. Waynesburg seems to be a favourite place for mining it, because of its gentle dip where the ridge ends. Opposite the end of Shade Mountain, S.E. of Lewistown, and S.W. of the Juniata, the hard ore sandstone folds over the axis, forming high land. The fossiliferous ore no doubt exists there, although it has never been exposed artificially.

Along the flank of Blue Ridge, not far from its base, the ore sandstone and ore crop out. The hard belt forms no ridge until the Surgent slates begin to leave the mountain towards its S.W. end in Huntingdon County. In Shank's Gap it is exposed near a sawmill; but near Galloway's Gap, on a farm of Mr Wharton's, specimens on the surface are common. Below Bell's Mill, where the Juniata washes the base of Blue Ridge, a steep cliff, called the Blue Rock, consists of the ore sandstone. The sandstone includes a variety of shades and textures; some layers are highly calcareous. In the midst of this mass, which is 30 feet or more in thickness, lies the fossiliferous ore. It is hard, calcareous, and of a reddish-brown colour. It is thin, and of small value. It dips 55° N.W.

Near Bell's Mill there commences a little ridge a few hundred yards from the foot of Blue Ridge, which is formed by the ore sandstone. Traced S.W., it bends in a semilunar crest round the termination of Blue Ridge, and bounds Germany Valley to the N.E. Where it curves round into the mouth of Negro Valley at Bell's Furnace, the fossiliferous ore has been mined. There are three layers, each 5 or 6 inches thick, and having considerable masses of sandstone above and below. The ore is hard, calcareous, and of a brown colour, and dipping 40° S.E. It is difficult to mine, and is not now used.

Germany Valley.—This is an area between Owen's Ridge and Blacklog Mountain, bounded on the N.E. by the little ridge which we have described, and on the S.W. by the points of several ridges. It is $1\frac{1}{2}$ miles wide, and $3\frac{1}{2}$ long, and contains the Scalent marls and limestone. The axis of Blue Ridge lifts the Scalent marls in a triangular form, and the synclinal trough between it and Blacklog Mountain, being a continuation of that of Negro Valley between Blacklog Mountain and Blue Ridge, embraces a long and narrow belt of Scalent limestone. On the S.E. side of Germany Valley, therefore, along the flank and base of Blacklog Mountain, ranges another belt of the marls and slates, dipping N.W.

Surgent Slates and Scalent Marls along the Blacklog Mountain.—From the S.W. end of Negro Valley to the termination of Blacklog Mountain, a distance of 18 or 19 miles, the outcrop of these strata ranges with great regularity. The rocks dip at a steep angle (60° to 70° N.W.), and extend up at least one-third of the whole height of the mountain. The debris of the mountain covers the belt to a great extent. Towards the end of Blacklog Mountain in Bedford County, the slate lies more at the base. At Littleton it unites with the belt on the S.E. side of Shade Mountain, and there spreads out over the anticlinal axis, conferring a good soil on several farms. (See the Sections.) If the ore exists, it will be found some distance up the slope of the mountain; but will probably be of little value, from its steep dip and its thinness. The ore sandstone is exposed at Littleton, but is only 10 or 15 feet thick. No ore was found with it.

Sulphate of Barytes.—This mineral is found in the upper part of the Surgent shales or Scalent marls, one mile N. of Fort Littleton. The larger masses, weighing from 20 to 30 lbs., are strewed loosely in the fields. They are bluish white and crystalline. Thin veins are seen *in situ* at Mr Roberts' limekiln. These are from $1\frac{1}{4}$ to 2 inches thick, enclosed in a soft matrix coloured by oxide of iron. The veins fill fissures transverse to the stratification. The mineral has evidently been formed after the contortion of the strata, apparently by infiltration.

This substance is used to mix with white-lead paint.

PIGEON COVE.

Surgent Marls.—This little valley, which is $1\frac{1}{2}$ miles wide at the State Line, and extends 6 or 7 miles into Pennsylvania, contains along its centre the Scalent marls, while the Scalent limestone skirts the sides. In Pennsylvania the Surgent slates are not developed, and we need not look, therefore, for the fossiliferous ore. Dingy buff-coloured and olive shales, with calcareous slates and sometimes considerable masses of dull argillaceous sandstones, constitute the strata here exposed. These layers are much contorted, five exposures of flexures occurring on the Little Conoloway Creek. The red shale does not appear in the Cove, though in this latitude it has still a thickness of about 100 feet. Probably, therefore, the variegated and grey marls are the only members visible below the limestone.

LITTLE SCRUB RIDGE.

Surgent Slates and Scalent Marls.—No doubt these strata exist on the N.W. flank of this ridge from the Burnt Cabins for 6 or 7 miles S.W., when they disappear in the fault. The whole of the flank and base of Scrub Ridge for that distance is covered with debris, and a careful examination revealed no exposures either of these or of the Pre-meridian limestones and Meridian sandstones, except in the gap near Harsley's Mill, between 5 and 6 miles S.W. of the Burnt Cabins, where the Surgent red shale is seen for some distance dipping 85° S.E.: it is slightly overturned.

Dickey's Mountain.—Emerging from the fault, the Surgent slates and marls appear on the S.E. side of Lowrey's Knob; from that, S.W., they flank Dickey's Mountain to its termination, reaching high on the slope of the mountain. The dip varies from the perpendicular to an inversion of 10°. The strata along this ridge cannot be studied minutely. As the mountain subsides, they lie more along its base, mantling round it once, the anticlinal axis of the Cove uniting with the same formation lying on the N.W. side of Little Cove. Opposite the junction of Dickey's and the Little Cove mountains, the iron and ore sandstones, here considerable masses, produce a semicircular ridge, represented on the map. These sandstone belts probably exist all along Dickey's Mountain, but they are only seen towards its S.W. end. Considerable search was made for fossiliferous ore, but none could be detected. It ought to be found in its usual relation to the ore sandstone, which it accompanies in the Little Cove. On Lowrey's Knob and on Dickey's Mountain, half a mile S.E. of Lower Hanover Forge, there is an ore of cellular structure, interstratified with the Surgent upper ore shales. There is reason to think it may range somewhat extensively.

Surgent Slates and Shales, and Scalent Marls, Little Cove.—These groups retain in the Little Cove their ordinary characters. The iron and ore sandstones are here considerably expanded, and somewhat changed in their aspect. They are each between 30 and 40 feet thick, and separated by about 75 feet of olive and buff slates, in which the fossiliferous ore occurs. Some of the strata of the ore sandstone are exceedingly massive, others are thinner. It is a hard and fine-grained white sandstone, with the impressions of fucoids on the surface. The iron sandstone is, as usual, of a dark red colour. It consists of massive strata, alternating with strata less massive and with red shale. Some of the sandstone contains small fragments of soft shale interspersed throughout its substance; this, on the weathered surfaces, washes out, leaving holes.

The Surgent rocks occupy the basin of Little Cove exclusively, from a point N. of Loudon, just where the Chambersburg turnpike enters through the gap to ascend Cove Mountain, to a point 9 or 10 miles S.W. Between the Chambersburg and Mercersburg roads, and for some distance S.W. of the latter, the surface is elevated and broken into abrupt little ridges, which are composed of the hard sandstone already described. The Chambersburg road ascends the N.W. flank of one of these ridges, the red iron sandstone having been used to mend the road. The strata in the synclinal trough dip from 30° to 40° S.E., and are perpendicular on the other side; we therefore find that the sandstone produces ridges only on the N.W. side of the basin, the other outcrop being in the slope of the Little Cove Mountain.

About 3 miles S.W. of the Mercersburg turnpike, in Little Cove, the Pre-meridian limestone and Scalent limestone commence in a narrow belt close to the base of the S.E. mountain. This belt divides the Surgent shales and slates into two tracts, one on each side of the Cove. Of these the N.W. is broad, forming the greater portion of the Cove, and reaching some distance up the mountain. Its strata generally dip 30° S.E., but they are much contorted. Further S.W. these contortions cease, and the limestones cross over towards the N.W. side, contracting the belt of Surgent rocks, although these dip nearly the same as before. This outcrop of the Surgent strata finally unites with the belt of Dickey's Mountain in the anticlinal tract, disappearing under the limestone a little S.W. of the Maryland line. Between the sandstone ridge and the Cove Mountain, the soft Surgent lower slate is degraded into a little valley, the waters of which pass through the ridge by gorges at intervals of about three-quarters of a mile.

The Surgent slates on the S.E. of the Little Cove lie entirely over the flank of the mountain, reaching at least two-thirds of its height, and in some places nearly to its crest. The rocks are perpendicular, and even inverted. (See the Sections.)

FOSSILIFEROUS ORE OF LITTLE COVE.

This ore lies in the shales between the two sandstones, or, in other words, it is the lower ore stratum. Its thickness is yet unknown, for want of good exposures. It was only detected by specimens on the surface. By these it was traced at intervals from the Mercersburg turnpike for 7 or 8 miles along the N.W. side of the Cove. It is found on the very crest of the sandstone ridge, in the little depression over the soft ore slates between the iron and ore sandstones. On the turnpike it can be found by observing that it lies above the red sandstone, which is there exposed. Its quality is good ; the specimens found are of the variety from which the calcareous matter has been dissolved. The dip is 30° S.E. None of the ore was found on the other side of the basin, although the red sandstone lies near the turnpike. The rocks there being perpendicular, it would be of less value, unless thick enough to mine into.

CHAPTER VI.

SCALENT AND PRE-MERIDIAN LIMESTONES.

Scalent and Pre-meridian Limestones, Lewistown Valley.—The Scalent limestone consists here of much calcareous slate, and limestone in flaggy beds. The upper portion is more massive. The Pre-meridian limestone consists of very massive layers of fœtid argillaceous limestone, of a dull blue colour and irregular fracture, with numerous organic remains. This latter formation, and the Meridian sandstone, from their greater hardness compared with the adjoining strata, everywhere form a ridge at their outcrop.

From Lewistown to Littleton the belts of limestone lifted by the anticlinal axes are very complex, and difficult to describe with precision. If the belt be narrow, with an anticlinal axis in it, then the Pre-meridian limestone forms a ridge, being flanked and protected by the Meridian sandstone ; but if the belt is monoclinal, the Pre-meridian limestone and Meridian sandstone together form a ridge, and the softer Scalent limestone lies at the base on one side. This is generally the case, though sometimes both the Pre-meridian limestone and Meridian sandstone are nearly levelled to the general surface of the valley.

GEOGRAPHICAL RANGE.

Between the first and second anticlinal axes, numbering them as before, there is a synclinal belt of the limestones. The hill on the Bellefonte turnpike, 1½ miles S. of Jack's Mountain, consists of the limestone of this belt, which, 1½ miles S.W. of the turnpike, is divided into two belts, by receiving the Meridian sandstone in the middle of the trough axis. The S.E. of these unites over the second anticlinal axis with a belt of limestone S.E. of it, while the N.W. one, traced S.W., borders the S.E side of Ferguson's Valley at the base of the bounding ridges. This latter dips 25° or 30° S.E It observes the same relations for 9 or 10 miles, until, nearly opposite Waynesburg, it unites in the extreme S.W. end of Ferguson's Valley, folding over the first anticlinal axis with a belt of limestone, which occupies the synclinal axis between the first anticlinal axis and Jack's Mountain for several miles N.E.

There is thus a belt of limestone, having three dips, in the very S.W. end of Ferguson's Valley, where it is quite narrow. The Meridian sandstone, beginning in the synclinal axis, divides this belt into two, which again unite 4 miles to the S.W., in the extreme N.E. end of Long Hollow. The formation is entirely covered by debris of the Levant white sandstone, and is uncultivated. The other belt, being the anticlinal one, with opposing dips of 40° N.W., and 80° S.W., composes a ridge flanked by the Meridian sandstone. Lying between Ferguson's Valley and Long Hollow, it is only some hundred yards wide. It passes a short distance N.W. of Huling's Saw-mill, on Fulling-mill Run, several miles S.W. of which it unites with the belt N.W. of it in the head of Long Hollow. The limestone then, with three dips, extends S.W., until it unites near Atkinson's Mill with the belt on the S.E. developed by the second anticlinal axis.

Limestones near the Second Anticlinal Axis.—As already mentioned, the second axis exposes a narrow strip of Scalent marls for nearly 2 miles S.W. of the Bellefonte turnpike. The limestone on each side, dipping in opposite directions, there meets the axis, and then ranges as one anticlinal tract for 16 or 17 miles S.W. to the Long Hollow, near Atkinson's Mill. This narrow strip extends along the ridges S.E. of Ferguson's Valley, near their N.W. summit, passing about a quarter of a mile N.W. of Hope Furnace, where it is only 200 or 300 yards wide. Traced S.W. it becomes wider. Its S.E. edge is a quarter of a mile or more N.W. of Brookland Furnace. The limestone outcrop occupies a ridge flanked with Meridian sandstone, until it reaches a point N.W. of the last-mentioned furnace. Thence S.W. for 2 miles or more, it is scooped out into a little valley, a quarter of a mile wide, through which the road to Atkinson's Mill passes. Where this valley ends the limestone again forms a ridge, flanked on the S.E. by the Meridian sandstone bordering Green Briar Valley. The belt merges into a wider one near Atkinson's Mill, by the ending of the ridge of Meridian sandstone N.W. of it. The N.E. extremity of the Long Hollow is thus formed of a broader belt of limestone, containing the S.W. ends of the first and second anticlinal axes. The belt is nearly one mile wide. The South-east-dipping strata of the second anticlinal axis form the basis of Long Hollow Ridge, separating Long Hollow from Green Briar Valley. Traced S.W., the Long Hollow becomes somewhat narrower, the anticlinal axes both die away, and the limestone becomes monoclinal, with a dip of 25° S.E., forming the S.E. side of the Long Hollow, and the base of Long Hollow Ridge. It thus continues until it reaches the Juniata, S.E. of Matilda Furnace, where the strata dip about 22° S.E., and the whole limestone belt is about half a mile wide.

Scalent and Pre-meridian Limestone, Hill Valley.—From the Juniata S.W., the same belt ranges parallel to Jack's Mountain, forming the S.E. side of Hill Valley, and the N.W. flank of Chestnut Ridge; its strata dip 25° S.E. Further S.W. the strata of Chestnut Ridge no longer compose a continuous ridge, and Hill Valley may be said to terminate, though the limestones preserve their usual dip, and their relative situation to Jack's Mountain. The belt lies considerably N.W. of Chester Furnace; traced South-westward, it folds round the end of Jack's Mountain at the Three Springs, and joins the belt of Hare's Valley on the N.W. side of the anticlinal axis. Where the Pre-meridian limestone and Meridian sandstone saddle the axis, they form a semicircular ridge, enclosing the fertile little area about the Three Springs.

Scalent and Pre-meridian Limestone, Third Anticlinal Axis.—The third axis develops a belt of the limestones extending from 1½ or 2 miles N.E. of Hope Furnace, for 7 or 8 miles to the S.W. Both Hope and Brook furnaces (nearly 5 miles apart) are on this tract, which is a narrow outcrop only 200 or 300 yards wide, occupying a ridge flanked on both sides by the Meridian sandstone, dipping steeply in opposite directions. About 1½ miles S.W. of Brookland Furnace it terminates, being there in the central part of the ridge, immediately N.W. of the turnpike.

Scalent and Pre-meridian Limestone, Fourth Anticlinal Axis.—The fourth anticlinal axis lies in the Pre-meridian limestone, where it is crossed by the Bellefonte Turnpike a little N.W. of the Toll-gate. It is there denuded into a hollow or ravine, but, followed to the S.W., it holds the ridge N.W. of Lewistown, flanked on both sides by the Meridian sandstone. It is 300 or 400 yards broad. About 5 miles S.W. of Lewistown, a short distance N. of the turnpike, it meets the belt of limestone, formed of North-west-dipping strata, which passes immediately by Lewistown. The synclinal belt of Meridian sandstones between these two limestone belts ceasing at the point where this takes place, there is a slight offset in the ridge, which ranges thence South-westward, formed of the strata N.W. of the fourth anticlinal axis. The S.E. belt of the limestone, traced from Lewistown S.W., is uniform until it reaches the point of union with that N.W. of it, about 1 mile N.E. of Stroud's Mill, and 5 miles S.W. of the town. Here the limestone has three dips, but the belt is still rather narrow. Where it is crossed by Brightfield's Run, the anticlinal axis is close to the base of the ridge N. of it, having a steep dip; and the South-west-dipping strata of the synclinal axis dip 30° N.W. One or two miles S.W. of Brightfield's Run, on which Stroud's Mill is situated, the fourth anticlinal axis terminates, and the limestone ceases in the synclinal axis S.E. of it, so that the belt, thence S.W., passing immediately N. of Waynesburg, is monoclinal, dipping 50° N.W. One mile S.W. of Waynesburg, the limestone again rises along the fourth anticlinal axis, and occupies the trough S.E. of it, and the belt has, a second time, three dips. It ranges thus for about one mile S.W., when the limestone of the synclinal trough widening and growing deeper, the Meridian sandstone enters it, and forms an elevated ridge, and divides the limestone belt into two; the most N.W. of these, traversed by the fourth anticlinal axis, and bordered by the sandstone on each side, passes in the N. side of the ridge S.E. of Green Briar Valley, and terminates 1½ miles from its separation, being succeeded by the sandstone. The other division, formed of strata inclined gently to the N.W., stretches S.W. to unite over the fifth anticlinal axis with the limestone in the synclinal trough S.E. of it. The Scalent limestone enters the trough between the fifth and sixth anticlinal axes opposite to Waynesburg. (See Section.) It gradually expands until its South-east-dipping strata join the belt last described, at a point 3 miles S.E. of Waynesburg, and a little N.W. of the Juniata River. We trace the belt thence for about 2 miles S.W., with three dips. The Juniata River runs along its S.E. edge, and it makes the S.E. escarpment of that wide ridge lying between the Juniata and Green Briar Valley. Five and a half miles below Newton Hamilton the Meridian sandstone, forming a cliff on the canal, commences in the synclinal trough between the fifth and sixth anticlinal axes, dividing the limestone belt we have just described into two. The North-western of these, containing the fifth anticlinal axis, is on the summit of the wide range N. of the Juniata. In the course of 1 or 2 miles the limestone becomes narrow, and disappears under the sandstone; but several miles S.W. it is again exposed, the sandstone on the fifth anticlinal axis being cut through at Beaver Run, 1½ miles N.E. of Newton Hamilton.

The other division, with a dip of 60° N.W., extends for about 2 miles S.W. (the Juniata River running upon it for that distance), to a point opposite Galloway's Gap. It unites over the sixth anticlinal axis by the disappearance of the Scalent rocks with the limestone of the synclinal trough S.E. of it.

The Scalent limestone enters the synclinal trough, between the sixth anticlinal axis and the Blue Ridge, some distance N.E. of Shank's Gap. (See Fig. 71.) Ranging S.W., it very gradually widens, until, as already mentioned, it unites over the sixth anticlinal axis with the strata to the N.W. opposite Galloway's Gap. But nearly opposite the same point, the Meridian sandstone enters the synclinal trough, forming, with the upper strata of the limestone, a ridge which rises S.W. of Mr Wharton's house, and runs to the Great Bend of the Juniata S. of Newton Hamilton. There are therefore two limestone belts, one N.W. and the other S.E. of the ridge described. The former is the continuation of the sixth anticlinal axis; it has steep dips, and is probably more than half a mile wide at first, but traced S.W. it becomes narrower. The upper strata, dipping N.W., form a broken ridge, so that the anticlinal axis for several miles runs in a little valley, the S.W. extremity of which is closed up before it reaches the Juniata at the bend, and a steep escarpment overhangs the river. Tracing the belt across the peninsula of the Juniata, it runs just S.E. of Aughwick Creek, and becomes the central part of Owen's Ridge. It occupies the crest of that ridge, and is only a few hundred yards wide, flanked on each side by the Meridian sandstone; it has also steep dips. Holding the same relations, this narrow zone of limestone is at last saddled by the sandstone, 5 miles from the Juniata, and same distance to the N.E. of Shirleysburg. The belt separating from the last on the S.E., near Galloway's Gap, dips 50° N.W., and forms the N.W. side of a little valley between the sandstone ridge and the Blue Ridge called Sugar Valley, which is 4 miles long. This valley ends at the bend of the Juniata, across which its belt of limestone is prolonged, passing N.W. of Bell's Mill, and bordering the N.W. side of Germany Valley, in the S.W. end of which it unites, over the anticlinal axis of Blue Ridge, with the same formation issuing from the synclinal trough of Negro Valley.

Pre-meridian Limestone, Prater's Ridge.—Prater's Ridge consists chiefly of the Meridian sandstone lifted along an anticlinal axis which originates about three-fourths of a mile S.E. of Newton Hamilton, and, crossing the Juniata twice, ends 3 miles from its origin. This ridge runs close to Owen's Ridge, and forms with it the narrow valley in which Aughwick Creek flows. The Pre-meridian limestone is developed in the central part of the ridge for one mile or more in length, but the belt is not much exposed.

Scalent and Pre-meridian Limestone, in the continuation of the Synclinal Trough of Negro Valley, and along the Anticlinal Axis of Blue Ridge continued.—Near the mouth of Negro Valley, S.W. of Bell's Furnace, the Scalent limestone commences, spreading out to the S.W., so as to form a considerable portion of Germany Valley. It is in the form of a synclinal trough, which, on the S.W. extremity of Germany Valley, receives Sandy Ridge, composed of the upper or Pre-meridian limestone and the Meridian sandstone. This ridge divides the limestone tract into two belts, the North-western of these uniting, over the anticlinal axis of Blue Ridge, with the limestone belt of Germany Valley. The tract thus formed is to be traced 3 miles further S.W., when it is closed by the sandstone of Sandy Ridge one mile N.E. of Orbisonia. The rocks on the axis are scooped into a little valley S. of Shirleysburg.

S.E. Side of Great Aughwick Valley.—The belt of limestone which lies S.E. of Sandy Ridge forms the N.W. part of a little valley at the base of Blacklog Mountain. Its strata very generally dip 45° N.W. Traced S.W., it ranges parallel to Blacklog Mountain, its S.E. border passing near Winchester Furnace, where the dip is 60° N.W. In this direction it is but seldom exposed, it is very near the base of the mountain, and much covered with debris. It lies S.E. of Madden's Mill, Huntingdon County, where it is entirely covered by fragments of the Levant white sandstone. Traced further to the S.W., it recedes more from the mountain, and is more exposed, forming part of a little valley between a ridge of the Meridian sandstone and Blacklog Mountain. For 2 miles S.W. of the line of Fulton and Huntingdon counties, Little Aughwick Creek flows in this belt, which has here a cultivated surface. S.W. of Fort Littleton, about one mile or more, it unites with the belt which ranges S.S.E. of Shade Mountain, over the prolonged anticlinal axis of Blacklog Valley.

Scalent and Pre-meridian Limestones, Pigeon Cove.—The limestones have here the same character which they possess in Mifflin County. The Pre-meridian limestone first reappears on the anticlinal axis at a point 7 miles N.E. of Werefordsburg, whence, for one mile or more, it forms a ridge flanked on each side by the Meridian sandstone. This ridge divides over the axis, and the two prongs enclose the Cove; at the dividing point the Scalent limestone appears, and further Westward the Scalent marls emerge, and separate the limestone into two belts. The zone on the N.W. side of the strata, which dip 60° N.W., passes into Maryland; its N.E. limit being about 1½ miles N.W. of Hancock, and that on the S.E. side ranges but a short distance N.W. of Hancock: this dips 40° S.E., the upper strata composing the N.W. flank of Conoloway Ridge, and the lower beds forming a level and fertile surface, which border the cove throughout.

Scalent and Pre-meridian Limestones, Little Scrub Ridge.—Near the Burnt Cabins the limestones dip perpendicularly along the N.W. side of the anticlinal axis of the cove, ranging in this attitude along the N.W. base of Little Scrub Ridge for 6 or 7 miles until they disappear in the fault. In all this distance there are no exposures or other indications of the strata, all the N.W. flank and base of Scrub Ridge being covered with debris. (See Fig. 53.) The limestone emerges from the fault on the N.W. side of Lowrey's Knob, where the dip is perpendicular. Thence they range close to the base of Dickey's Mountain S.E. of Hanover Furnace and Forges, preserving the same attitude. Towards the S.W. extremity of Dickey's Mountain, the belt recedes from the base a little, and, crossing the corner of Franklin County, passes into Maryland, where it unites with the zone of the same rocks coming from Little Cove, over the anticlinal axis of McConnellsburg Cove.

Scalent and Pre-meridian Limestones, Little Cove.—Commencing 3 miles S.W. of the Mercersburg Turnpike, the limestones in Little Cove form a narrow strip lying a short distance from the base of Little Cove Mountain, the strata dipping 30° S.E. on one side of the synclinal axis, and on the other being perpendicular. About 3½ or 4 miles N.E. of the Warren Ironworks, the Meridian sandstone and Cadent slate begin to occupy the synclinal axis dividing the belt of limestone into two parts. The North-western of these crosses towards the N.W. side of the Cove, along which it stretches, dipping 30° S.E, with its S.E. limit three-fourths of a mile N.W. of Warren Ironworks. Preserving the same bearing (S. 30° W.), it passes the State line, S.W. of which it unites, over the prolonged anticlinal axis of the Cove, with the belt N.W. of Dickey's Ridge. The S.E. zone keeps a position near the base of Little Cove Mountain ; its strata are perpendicular, and in some places overtilted so as to dip steeply S.E. There is a small axis or wrinkle in it for several miles before it is crossed by the State line, the Meridian sandstone lying in the synclinal axis between this axis and the mountain. This separates it into two slender zones, the North-western an anticlinal belt, and the South-eastern dipping to the N.W. The surface is much strewn with debris. The Meridian sandstone and Pre-meridian limestone form a chain of hills near the foot of the mountain.

CHAPTER VII.

MERIDIAN SANDSTONE OF THE BELT.

Where this formation occupies a synclinal trough between any of the axes which have been described, it just caps, if it be narrow, the summit of a ridge with a single crest. If, however, it be wider, each outcrop of the formation gives a separate crest between which lies a trough usually more elevated than the surrounding country, produced by the erosion of the Cadent black slate. From the thinness of the sandstone, we almost invariably find that the lower strata of the Cadent black slate are included in the synclinal axes, affording a singular and beautiful provision for the preservation of the great bed of iron ore which exists low in this slate.

Meridian Sandstone in the Synclinal Trough N. of the First Anticlinal Axis.—The sandstone forms a narrow belt in this synclinal basin from a point N.W. of Waynesburg, for 4 miles S.W. to a point about one mile N.E. of Atkinson's Mill. The rocks dip towards each other at an angle of 50°. The two outcrops of the sandstone, which are very evident at several points examined, are about 200 yards asunder. The South-eastern one, dipping to the N.W., and flanked by the limestone, is elevated by the first anticlinal axis.

The group of ridges between the turnpike from Lewistown to Waynesburg on the S.E., and Ferguson's Valley on the N.W., has in it several synclinal axes containing the Meridian sandstone and the Cadent black slate. The trough-like structure, produced by the washing away of the black slate, is often very evident. But these little troughs or valleys are more elevated than the surrounding country, so that the mass is generally viewed as a single ridge.

Meridian Sandstone, Axis of First and Second Anticlinal Axes.—About a mile S.W. of the Bellefonte Turnpike, the sandstone begins to show itself in the synclinal axis of the first and second anticlinal axes ; and from thence S.W. for 17 miles it exists as a narrow trough from 200 to 300 yards wide, but is frequently narrower. It lies close to the S.E. side of Ferguson's Valley, forming the base and the flank of the ridges. It is for some distance nearly levelled, the limestone S.E. of it forming the slope of the ridge. It is one-fourth of a mile N.W. of Hope Furnace, where the South-east-dipping strata are inclined at an angle of 30°, and the N.W. dip 80°. Traced S.W. for 4 or 5 miles, it is cut through by Holliday's Run at Kinsell's Sawmill. There it includes a narrow belt of the black slate between the two outcrops. Thence it ranges S.W., and past Huling's Sawmill, which stands on the black slate embraced in the trough ; its S.E. dip here is 60°, and its N.W. dip 70°. From this point it can be traced 5 miles S.W., until it ends a short distance N.E. of Atkinson's Mill, in the N.E. end of Long Hollow. The synclinal belt thus followed exhibits the sandstone in a double line of outcrops, with a narrow zone of slate the greater part of the distance along the middle of it.

Meridian Sandstone, Synclinal Trough between the Second and Fourth Anticlinal Axes.—Near the point where the Bellefonte Turnpike crosses the synclinal trough between the second and fourth anticlinal axes, the sandstone no doubt exists, though partially levelled and cultivated. Traced S.W., it becomes more distinct, the strata on both sides being nearly perpendicular, forming two crests, embracing between them a trough in the black slate. This is the state of things about a mile N.W. of Lewistown, in the ridges. Followed S.W., the ridge grows wider, and 2 miles N.E. of Hope Furnace it is one-fourth of a mile wide, the trough between being excavated nearly to the level of the surrounding country. At this point the third anticlinal axis originates, lifting the Pre-meridian limestone in a ridge, flanked by the Meridian sandstone. This ridge passes Hope Furnace. The wider synclinal trough is therefore separated into two narrower ones, which range with much regularity S.W. until they again coalesce, 8½ miles distant, in the N.E. extremity of Green Briar Valley, by the dying-away of the included third anticlinal axis and its ridge.

The North-western of these minor troughs lies 200 yards N.W. of Hope Furnace, where it is seen finely exposed, the outcropping sandstone dipping at an angle of 80° on each side, with the black slate between them. At this place it is cut down, and Brightfield's Run flows along it for a short distance. Traced S.W., it rises again, and shows the trough-like structure described. It passes 200 or 300 yards to the N.W. of Brookland Furnace, where it is cut through by Holliday's Run, S.W. of which it is indicated by an excavation for ore in the black slate; and the sandstone may be seen on each side dipping steeply towards the synclinal line. Traced S.W., we find a very regular trough several hundred yards broad, the sandstone forming the slopes. The N.W. dips are more gentle near the termination of the third anticlinal axis, until they finally end with the belt 2 miles or more S.W. of Brookland Furnace, in the N.E. extremity of Green Briar Valley; the South-east-dipping strata, passing on S.W., flank the bridge bounding Green Briar Valley on the N.W. side. Laughlin's Sawmill is situated on this zone, a few hundred yards N.W. of the termination of the third anticlinal axis, and at that point there is a roll in the dip, extending for 1 or 2 miles at the base of the ridge. For several miles further S.W. the same belt dips uniformly S.E.

Long Hollow Ridge.—This part of the sandstone lies between the Long Hollow on the N.W. and Green Briar Valley on the S.E. We trace it with a dip of 30° until it reaches the Juniata River at the aqueduct below Drake's Narrows. Following the same outcrop across the Juniata, it is seen on the S.E. side of Chestnut Ridge, which separates Hill Valley from Great Aughwick Valley, this ridge being continuous and regular with the same dip for 8 or 9 miles S.W. of the Juniata.

Chester Furnace lies one-fourth of a mile S.E. of it. Further S.W. for several miles the ridge is broken, being degraded in many places into a chain of knolls. This feature appears to have been produced by the great current which swept across the top of Jack's Mountain and the whole mountain-chain of the State. Following the belt still S.W., it forms the semicircular ridge which sweeps round the end of Jack's Mountain, enclosing the area about the Three Springs, and there uniting with the corresponding outcrop which forms Rocky Ridge of Hare's Valley.

Near Chester Furnace there is an ore in this formation, which will be noticed in the section on ores. We have now to trace that synclinal belt of the Meridian sandstone which is S.E. of the third anticlinal axis. Its South-east-dipping strata are only 100 yards S.E. of Hope Furnace, and its North-west-dipping strata, nearly perpendicular, are 300 or 400 yards further to the S.E. Where it is cut by the gorge of Brightfield's Run, it is in the form of a trough, which to the S.W. becomes narrower, more elevated, and indistinct. About 2½ miles from Waynesburg, it is intersected by the notch of another run, from which S.W. its North-west-dipping strata are partially or entirely levelled, and it forms the flank and crest of the ridge seen immediately N.W. of the turnpike. Creswell's Ore Bank lies in the black slate embraced in that part of the trough opposite to Waynesburg and S.W. of Brookland Furnace. One set of strata dips 65° S.E. from the slope of the ridge, while those dipping N.W. are entirely levelled, together with the black slate between them, which is seen on Holliday's Run in an excavation made in search of coal. Near the same place, some of the strata of sandstone on the S. side of the trough are exposed by an excavation. They consist of a very pure white sandstone, disintegrating, the cement having been dissolved. This has been suggested as a fit material for the manufacture of glass, for it is extremely pure, and might be procured with great ease.

The synclinal belt, for 1½ miles S.W. of Waynesburg, is found in the same condition—viz., the S.E. side denuded to the lowest level. The outcrop of the sandstone on the opposite side then begins to separate, and the black slate lies between in greater quantity. The South-east-dipping strata become less inclined, and finally overlie the subsiding third anticlinal axis. The North-west-dipping strata, crossed by the turnpike entering the head of Green Briar Valley, seek the S.E. side of that valley, form the border of the ridge bounding it on the S.E., and unite 1½ miles distant over the fourth anticlinal axis with the strata S.E. of it.

Meridian Sandstone, as it occurs in the Synclinal Trough between the Fourth and Fifth Anticlinal Axes.—The Bellefonte Turnpike crosses this trough of the sandstone N. of Lewistown. The toll-gate stands on its N.E. outcrop. Its width is considerable, and it contains a belt of the black slate N.W. of Lewistown. The strata on both sides form evident crests, but further S.W. the North-west-dipping strata are partially levelled, those with a S.E. dip flanking the ridge. The inclinations are 80° S.E. and 70° N.W. The synclinal belt continues with the same features, until the sandstone ceases, about 5 miles S.W. of Lewistown. The turnpike is upon it, towards the South-western part of its range. About 8 or 9 miles further W., and 2 miles or more S.W. of Waynesburg, the sandstone again occurs, between the same lines of elevation, in the high broad ridge commencing there, to the S.E. of Green Briar Valley. Its South-east-dipping strata are united with the belt N.W. of it, which has been described over the fourth anticlinal axis, which stretches S.W. in the sandstone for 5 miles ; this terminates at Glasgow's Mill, where the black slate saddles it. The dips in this part of the belt are gentle (see Sections), and the part of the ridge nearest Green Briar Valley is composed of the sandstone on the anticlinal axis. The Cadent lower slates may possibly exist in the synclinal axis S.E. of it; but this is merely hypothetical. The North-west-dipping strata of the trough towards the S.E. side of the wide ridge unite over the fifth anticlinal axis, with the sandstone occupying the synclinal trough between the fifth and sixth anticlinal axes.

Meridian Sandstone, Synclinal Trough between the Fifth and Sixth Anticlinal Axes.—About 5½ miles below Newton Hamilton, and nearly opposite Shank's Gap, the sandstone begins to appear in the synclinal trough of the fifth and sixth anticlinal axes, forming a hill overhanging the canal. Traced S.W., the canal and river coincide with its S.E. limit. Its South-east-dipping strata unite over the fifth anticlinal axis with the North-west-dipping strata N.W. of it, and then for several miles S.W. the ridge, which is between the Juniata and Green Briar Valley, is traversed by the fifth and sixth anticlinal axes, lifting the sandstone into gentle inclinations. The former of these ends at Glasgow's Mill, but the latter, cut through by Beaver Run, S.E. of Glasgow's Mill, extends for 2 miles further, and ends a little S.W. of Newton Hamilton, which stands upon it.

The synclinal trough of the sandstone S.E. of the fifth anticlinal axis, where it is crossed by Beaver Run, is about one mile broad, yet from the gentleness of the dips, the result of a flat undulation or swell in it, the black slate does not here lie in it, nor probably at any other point to the N.E. Somewhere not far N.E. of the mouth of Beaver Run, the lower layers of the Cadent black slate begin to appear in the synclinal trough. The S.E. outcrop crosses the river obliquely one-third of a mile below the Newton Hamilton dam, whilst the belt on the other side of the trough terminates in a rather broad tract N.E. of the river in the neighbourhood of the dam, being spread out thus by a roll of limited extent. No belt of black slate separates this part of the tract from that exposed along the fifth anticlinal axis. There is a variation in the character of the sandstone in the neighbourhood of Newton Hamilton which may be here noted. The upper beds are more than usually calcareous, being of a blue colour and very fossiliferous. Where they are long exposed, the rock becomes, by the solution of the lime, soft and brown. These beds may be well seen at the dam, where they are elevated by the short axis, and both N.E. and S.W. of the town, where they are elevated along the fifth anticlinal axis.

The belt of sandstone dipping N.W., which, as has been mentioned, crosses the Juniata half a mile below the Newton Hamilton dam, flanks the broken ridge seen one mile S.E. of that town. Traced S.W., it crosses the Juniata twice at its bend, and, passing the mouth of Aughwick Creek, forms with Prater's Ridge a narrow trough, and flanks the N.W. side of Owen's Ridge. Where this zone forms part of Owen's Ridge, the dip of the strata is steep. It folds over the extremity of Owen's Ridge at the town of Shirleysburg, meeting the corresponding outcrop S.E. of the sixth anticlinal axis.

Meridian Sandstone, Prater's Ridge.—The anticlinal axis of Prater's Ridge begins to expose the sandstone about one mile S.W. of Newton Hamilton, on the opposite side of the Juniata. From thence we may trace it with two opposite and gentle dips, crossing the Juniata River twice at its bend, and forming within the loop of the river a round hill. It is only S.W. of the Juniata that the belt is called Prater's Ridge. This ridge is low and broad, or about one-third of a mile wide through the base. It extends for one mile or more S.W. of the Juniata. The strata flanking it on the N.W. dip gently to the N.W., while those on the S.E. dip 40° S.E., forming with Owen's Ridge the narrow synclinal axis in which Aughwick Creek here flows. The two outcrops on the opposite sides unite S.E. of Mr Morrison's, and the formation disappears under the Cadent and Vergent strata of the synclinal basin of Great Aughwick Valley.

Meridian Sandstone—Synclinal Trough S.E. of the Sixth Anticlinal Axis.—It has been already noticed that the sandstone begins to appear in the trough between the sixth anticlinal axis and blue ridge, nearly opposite Galloway's Gap. To the N.E. it forms the crest of a ridge with a sharp summit, but traced S.W. when it reaches the Juniata, nearly 4 miles distant, it is wider, embracing a belt of the Cadent black slate, in which occurs Mevey's Ore Bank. A little S.W. of Mevey's Ore Bank, which lies quite high, the opposite outcrops of this synclinal trough are seen about 200 yards apart, in a perpendicular position, forming distinct crests, with the trough of slate between them. (See Fig. 73.) Followed S.W., the belt in the area included by the bend of the Juniata is cut down to the common level. But S.W. of the bend of the river it rises again into a ridge, which is the N.E. extremity of Owen's Ridge, where Bell's Ore Bank lies in the black slate embraced by the two outcrops. Traced further S.W., this synclinal belt lies S.E. of the crest of Owen's Ridge, and has its North-west-dipping strata somewhat degraded. Pursuing it still S.W., a ridge is observed to separate from Owen's Ridge, leaving an elevated trough between them. This is formed of the North-west-dipping strata or S.E. outcrop of this belt, while the N.W. outcrop flanks the main crest of Owen's Ridge on the S.E., the soft black slate between them being eroded. Tracing the N.W. outcrop, it is seen to sweep over the extremity of Owen's Ridge at Shirleysburg.

The S.E. outcrop, forming a lower and more broken ridge, lies from 500 to 600 yards S.W. of that town, and S.W. unites over the prolonged anticlinal axis of Blue Ridge, 2½ or 3 miles from Shirleysburg, with the corresponding outcrop of the synclinal axis to the S.E., which is now to be described. The junction of these two belts near the declension of the Blue Ridge anticlinal axis, forms what is called Sandy Ridge.

Meridian Sandstone in the Synclinal Axis S.E. of the Anticlinal Axis of Blue Ridge.—In the S.W. part of Germany Valley, a ridge originates called Sandy Ridge. It is composed of the Pre-meridian limestone in its base, and the Meridian sandstone in its crest, and has a synclinal structure, being a continuation of the trough of Negro Valley. The sandstone here forms a narrow belt for several miles, until oppositely-dipping strata begin to separate, when the ridge forks. The N.W. belt unites with that N.W. of the Blue Ridge axis just described, forming the end of Sandy Ridge, at the town of Orbisonia. The S.E. belt of the synclinal trough, its strata dipping 65°, lies one-third of a mile S.E. of the town, and forms the obscure ridge to the S.E. of the ore-banks in that vicinity. This zone, traced S.W., ranges parallel to and near the base of Blacklog Mountain, and is that outcrop of the sandstone which forms the S.E. side of the synclinal basin of Aughwick Valley.

Meridian Sandstone in Great Aughwick Valley.—The sandstone ranges for several miles S.W. of Orbisonia, or rather of Winchester Furnace, a short distance N.W. of which it passes a distinct ridge, somewhat broken, but further S.W., passing S.E. of Madden's Mill, it is cut down for some miles and covered with debris; but about one mile beyond the mill, and thence across the Fulton County line, it again forms a distinct ridge a few hundred yards from the base of the mountain.

In Fulton County the ridge is regular on the N.W. side of Little Aughwick Creek, which passes half a mile N.W. of Fort Littleton. The dip of the strata is 30° N.W. About 2 miles S.W. of Fort Littleton, and 3 miles from the actual termination of Blacklog Mountain, this belt meets that which ranges S.E. of Shade Mountain. The outcrop in the latter belt is thinner, showing a diminution of the formation towards the S.E., which is still more evident in another belt to be presently described. The sandstone S.E. of Fort Littleton does not form a ridge. Some of the strata are highly impregnated with oxide of iron, but there is probably no ore in this neighbourhood.

Meridian Sandstone, Pigeon Cove.—The sandstone rises from beneath the Cadent black slate on the Pigeon Cove axis, about 7 miles N.E. of the State line. It here forms a single ridge with the Pre-meridian limestone between its two outcrops, but further S.W. this ridge divides into the two monoclinal ones, called the Conoloway ridges, which enclose Pigeon Cove. These are each about 100 feet high. The W. one contains on its N.W. flank the sandstone dipping 60° N.W., which ranges in a straight line to the Maryland boundary, where it is 1½ miles from the other, or S.E. Conoloway Ridge.

The S.E. ridge contains the sandstone on its S.E. flank, dipping at an angle of 40° S.E., the Pre-meridian limestone occupying its N.W. side. Its direction is nearly straight. Where it is cut through by the gorge of Conoloway Creek, there is a fracture in the strata which is half a mile long, extending obliquely through the ridge in a N.E. and S.W. direction, and the creek flows along the line of the dislocation. The strata S. of the fault are heaved past those N. of it, so as to dip in the same direction, or S.E. At one point the sandstone abuts against the limestone, and towards the S.E. extremity the Cadent black slate lies against the limestone.

This ridge crosses the State line near Hancock, N.W. of which town it reaches the Potomac.

The sandstone in the S.E. Conoloway Ridge is more than 150 feet thick, and it rapidly increases N.W. The great body of it is a coarse brown sandstone, with the characteristic fossils. There are some layers of a conglomerate, consisting of quartz pebbles, from the size of a pea downwards; and where this rock is disintegrated, there is generally soil.

Meridian Sandstones, Little Scrub Ridge, &c.—The Meridian sandstone is not exposed on the S.W. side of Scrub Ridge, for reasons already stated. Where it first disappears in the fault with the adjoining limestones, it cannot be seen. (See Fig. 53.)

Dickey's Mountain.—The sandstone emerges from the fault on the N.W. side of Dickey's Mountain with a perpendicular dip. There, and all along the base of Dickey's Mountain, the formation is only a few feet thick. It consists of very calcareous sandstone, and a conglomerate formed of small quartz pebbles cemented by lime. The usual fossils are found in it. It does not constitute a ridge, but ranges at the foot of Dickey's Mountain, passing a short distance S. of Hanover Ironworks, and it crosses a corner of Franklin County into Maryland.

Meridian Sandstone in Little Cove.—In the Little Cove this rock consists of layers of fine conglomerate and coarse sandstone much impregnated with iron. Its thickness is about 30 feet. It is first found in the synclinal axis of the Cove, 5 or 6 miles S.W. of the Mercersburg Turnpike, and 3 or 4 miles N.E. of Warren Ironworks. Soon it separates into two belts, with the Cadent and Vergent strata between, that on the N.W. side extending 5 or 6 miles to the Maryland line, passing three-quarters of a mile N.W. of Warren Furnace, and forming the S.E. flank of a considerable ridge, which is barren, and broken by several gaps. The strata are inclined at an angle of 30° S.E.

On the S.E. side of the synclinal axis the sandstone preserves a position close to the base of the Little Cove Mountain, and with a nearly perpendicular dip or even an inverted one. It comprises the N.W. flank of a broken ridge of insignificant height. Passing one-fourth of a mile S.E. of Warren Ironworks, the belt extends into Maryland, and where crossed by the State line it is 1½ miles from the same formation on the other side of the basin.

The sandstone also occurs in a narrow synclinal zone close to the base of the Little Cove Mountain, extending 3 or 4 miles in Pennsylvania, forming a chain of hillocks scarcely distinct from the slope of the mountain, with a surface covered by debris.

CHAPTER VIII.

CADENT AND VERGENT STRATA IN THE BELT.

From the steepness of the dips along the subordinate flexures which traverse the valley S.E. of Jack's Mountain, and the slight thickness of the Meridian sandstone, we find the Cadent black slate lying protected in almost all the synclinal troughs of that sandstone. As a general condition, where these belts of slate are very narrow, the slate is rarely seen exposed, being covered by the sandy soil of the sandstone outcropping on both sides; but wherever the outcrops of Meridian sandstone on the opposite sides of a synclinal trough are a certain distance asunder, and the dips steep, we may know positively that the black slate, and probably the iron ore, are present. In tracing these thin strips of the slate, it is not asserted that the ore will be found continuously along their whole course, for it may happen that the ore stratum either thins out, or loses its aspect as ore, from a diminution in the proportion of carbonate of iron.

The best ore-banks which are opened, observe a general correspondence in their position. They are all somewhat elevated, and are so situated that small streams or springs, either at present or at some past period, have trickled through the ore-bed, aiding greatly in the conversion of the carbonate of iron into the softer peroxide.

Cadent Lower Black Slate—Synclinal Trough between the First Anticlinal Axis and Jack's Mountain.—No black slate occurs in this synclinal axis, but at the several points where it was examined, the low crests formed by the opposite outcrops of the sandstone are from 150 to 200 yards apart, the South-east-dipping strata being somewhat degraded; so that the black slate probably exists in the little terrace between them. Of course, its extent and position are nearly the same as that of the enclosing sandstone of the same trough, which has been already traced.

Synclinal Trough of the First and Second Anticlinal Axes.—This belt stretches along the S.E. side of Ferguson's Valley, as was noticed in describing the sandstone. No exposure of the slate was seen N.E. of the point where the ridge is cut by Holliday's Run, near the S.W. extremity of the valley; yet it may exist.

The sandstone in this part of the synclinal axis has been much denuded. At Holliday's Run, below Kinsell's Sawmill, the black slate is seen exposed, and from that point S.W. for 2 miles to Huling's Sawmill, an elevated trough indicates the situation of the slate, which forms a belt several hundred yards wide. Huling's Sawmill is situated on the black slate, whence it can be traced S.W. for about 2½ miles; the road to Atkinson's Mill runs on it for a considerable distance in that part of its course. Toward the S.W. extremity it is indicated by an ore-bank formerly wrought for Brookland Furnace north of Atkinson's Mill. It is highly probable that much ore remains undeveloped along this trough.

Cadent Lower Black Slate—Synclinal Trough of the Second and Fourth Anticlinal Axes.—Where this synclinal trough is crossed by the Bellefonte Turnpike, the existence of the slate is uncertain, but traced further S.W., the sandstone belt widens, and a very evident trough shows that the slate exists, though it was not seen exposed. About one mile N.E. of Hope Furnace this trough is nearly one-fourth of a mile wide, bounded by nearly perpendicular walls of the sandstone, the slate without doubt underlying it. The third anticlinal axis there originates, exposing the sandstone, and separating the slate into two narrow belts, which unite again where that axis ends.

The more North-western of these little zones passes several hundred yards N.W. of Hope Furnace. Brightfield's Run flows on it for a short distance, the black slate being exposed there, whence it stretches S.W. in a straight line until it is cut through by Holliday's Run several hundred yards N.W. of Brookland Furnace. Its position is shown by an ore-bank. Followed S.W., it is denuded into a very regular trough, which gradually widens out into the N.E. extremity of Green Briar Valley. There is good reason to suppose that much ore may yet remain undiscovered along this narrow belt.

Belt S.E. of the Third Anticlinal Axis.—This little belt passes a few hundred yards S.E. of Hope Furnace, being degraded into a very regular trough. An ore-bank lies on this part of its course. Traced S.W., the trough gradually becomes indistinct, and, ranging in a straight line for several miles N.E. of Waynesburg, follows the flank of the ridge immediately N.W. of the turnpike, and passes Creswell's Ore Bank, which is in it. Still further S.W. it becomes lower, and on Holliday's Run N.W. of Waynesburg, and S.E. of Brookland Furnace, it is entirely levelled. An excavation from 100 to 200 yards wide has been made there in the slate, in search of coal. For nearly 2 miles it is narrow, lying near the base of the ridge.

The North-west-dipping strata of the sandstone being levelled, the belt, now becoming wider, coalesces with that N.W. of it, in the N.E. end of the Green Briar Valley, by the termination of the sandstone ridge, lifted by the third anticlinal axis S.E. of Laughlin's Sawmill. Beyond this we have the wider belt of Green Briar Valley, the description of which comes next in order, but convenience requires that other belts should be previously traced.

Cadent Lower Black Slate—Trough between the Fourth and Seventh Anticlinal Axes.—Where this trough is crossed by the Bellefonte Turnpike just at the toll-gate, the black slate is seen forming a belt several hundred yards in width. It may also be observed N.W. of Lewistown, where its soil is cultivated. Thence S.W. it probably extends for several miles, lying near the base of the ridge; and though no exposures were seen in that part of its course, the synclinal axis in the sandstone indicates its extent. We know of no ore having been found in it. It is highly probable that the black slate exists between the same lines of outcrop along the ridge which extends between the Juniata and Green Briar Valley. The surface of that ridge is barren, sandy, and uncultivated.

Trough between the Fifth and Sixth Anticlinal Axes.—This synclinal axis does not embrace the black slate, although the sandstone is spread out over a considerable width, because the strata along the middle are nearly horizontal. Towards its S.W. termination, to the E. of Newton Hamilton, the slate does occur in it, becoming soon more than a mile in width. The farms on the opposite side of the Juniata, from Newton Hamilton, are on it. The anticlinal axis of Prater's Ridge, rising in the S.E. side of this district, throws up the sandstone, and separates the slate into two belts. The South-eastern of these, being 200 or 300 yards wide, can be traced across the Juniata twice, and then along the banks of Aughwick Creek between Prater's and Owen's Ridges; and where Prater's Ridge ends, it again joins the main belt. The black slate, separated on the N.W. of the Prater's Ridge axis, unites with the belt continued from Green Briar Valley, from which it is divided at Newton Hamilton merely by a narrow belt of arenaceous limestone, considered to belong to the Meridian sandstone, thrown up by the subsiding end of the anticlinal axis.

Cadent and Vergent Rocks in Juniata or Green Briar Valley.—This is a synclinal trough of the Cadent black slate, with gently-dipping strata. Its N.E. termination is 2 miles from Waynesburg, where the two narrow belts of slate, on each side of the anticlinal axis, coalesce with the ending of that axis. Traced S.W., the slate belt, nearly one mile wide, is bounded by ridges of the sandstone on both sides. Where the fourth anticlinal axis ends at Glasgow's Mill, it is most expanded, being there 1½ miles in breadth, growing narrower towards the S.W. by a change in the course of Long Hollow Ridge.

The Cadent lower shales, and perhaps even higher Vergent rocks, form considerable hills, and there is a regular synclinal basin, with gentle dips, between Long Hollow Ridge on the N.W. and the belt of sandstone containing the S.W. end of the fifth anticlinal axis, passing through Newton Hamilton on the S.E. (See Fig. 73.)

Where the sandstone on the fifth axis ceases to be exposed to the S.W. of that town, and Prater's Ridge axis commences lifting the same formation three-fourths of a mile to the S.E., the united belt crosses the Juniata River, and S.W. of the river ranges between Chestnut and Prater's ridges, forming the N.E. extremity of Aughwick Valley. It is there a regular synclinal trough with gentle dips, a range of hills formed of the Post-meridian flags existing towards the N.W. side.

About 2 miles S.W. of the Juniata, Prater's Ridge terminates, and the narrow zone of Cadent and Vergent rocks, which is included between it and Owen's Ridge, unites with the wide synclinal basin of the same formation of Great Aughwick Valley, and thence S.W. for 3 miles to Shirleysburg, the Cadent and Vergent strata fill the whole district between Owen's and Chestnut ridges. This is about 1½ miles wide, with a chain of hills composed of the Vergent flags towards the N.W. side.

Iron Ore.—There are no excavations for the iron ore in Green Briar Valley, although the part of the formation in which it should occur crops out on both sides of the basin; neither are there any in the black slate immediately in the S.E. of Newton Hamilton, nor had ore been developed in the belt between Prater's and Owen's ridges at the time of the survey there, although it seemed very probable that a proper search would lead to its discovery.

Morrison's Ore Bank, which is a very valuable one, lies N.W. of Prater's Ridge, nearly opposite its S.W. termination. The strata dip very gently N.W., being the S.E. outcrop of the Great Aughwick Valley Basin, on the N.W. side of which, near the base of Chestnut Ridge, not far from the Juniata, there are also indications of the same kind of ore in a corresponding position in the strata. Where Owen's Ridge and the sixth anticlinal axis forming it terminate at Shirleysburg, a narrow zone of the Cadent slate on the S.E. side of it unites with the main synclinal basin.

Cadent Black Slate—Synclinal Trough between the Sixth Anticlinal Axis and Blue Ridge.—Mevey's Ore

Bank is the most N.E. point where the black slate is unequivocally displayed, although it may exist some distance further N.E. It is there near the top of the ridge which bounds the little valley, sometimes called "Sugar Valley." From Mevey's Ore Bank, in a straight line bearing about S. 30° W., and one mile distant, is Bell's Ore Bank, on the N.E. end of Owen's Ridge. These two are in the prolongation of the same synclinal belt, although the black slate between them is wanting, having been swept away from the area enclosed by the Great Bend of the Juniata River. At Bell's Ore Bank, the zone is only 100 or 200 yards wide, and it is not at first apparent that it really is the slate embraced by the sandstone. Following this narrow strip S.W., it ranges along S.E. of the crest of Owen's Ridge, and as it approaches Shirleysburg it becomes wider, and descends more to the level of the surrounding country, while the North-west-dipping strata of the sandstone, limiting it on the S.E., take more distinctly the form of a ridge diverging from Owen's Ridge.

The belt finally coalesces with the main synclinal axis at Shirleysburg, its S.E. limit being marked by a chain of sandstone knobs 400 or 500 yards S.E. of that town.

From Shirleysburg S.W. to Orbisonia, a distance of 4 miles, we trace the S.E. limit of the Cadent rocks. The belt is bounded by North-west-dipping strata of the sandstone, which, towards the latter town, flank Sandy Ridge. Chestnut Ridge bounds these strata on the N.W.; they therefore occupy the whole synclinal basin of Great Aughwick Creek. Ridges of grey sandstone, probably the Vergent flags, occupy the central part of this valley. One of these to the N.W. of Orbisonia receives the name of Saddleback Ridge. It bounds a little valley of the Cadent lower black slate between it and Sandy Ridge. The S.W. extremity of Sandy Ridge is at the town of Orbisonia, where the zone of black slate on the S.E. of it unites with that of the main synclinal basin. I proceed to describe the *Cadent Black Slate Basin.*

Synclinal Basin, which is the Prolongation S.W. of that of Negro Valley.—A number of ore-banks are situated in this synclinal trough. It is attenuated to the N.E., and probably occupies the crest of Sandy Ridge for a great part of its course, but towards the S.E. it widens out and becomes a little valley between ridges of the sandstone, and here the ore-banks alluded to occur. The ore has been used successively by several furnaces; most of the openings being on the North-west-dipping strata, which have a steep dip. It is probably lifted to the surface by contortions at other points near the mouth of the synclinal valley.

From Orbisonia S.W., Great Aughwick Valley has a simple synclinal structure between the anticlinal axis of Jack's Mountain and Blacklog Valley. The N.W. dips are considerably steeper than the S.E. ones, and the whole of the central part is occupied by the Cadent, Vergent, and Ponent rocks, forming a very irregular hilly surface. From Orbisonia to the N.W. limit of the Cadent and Vergent rocks, near Chester Furnace, the distance is 2¾ miles, those strata occupying all the intervening space. (See Section 20.)

The Ponent Strata from the High Land S.W. of the Junction of Three Spring and Great Aughwick Creeks, and between them.—This point is the N.E. termination of a belt of these rocks which stretches thence to the S.W. On each side of this Ponent belt, the entire Cadent and Vergent series crop out, bordering Great Aughwick Valley. The N.W. belt dips uniformly 40° to the S.E., and stretches for 4 or 5 miles S.W., underlying a district 1¼ miles wide, when it folds over the axis of Jack's Mountain about 1½ miles S.W. of the termination of Cheat Mountain, and is united with the belt which traverses the S.E. portion of Hare's Valley. Where this union takes place, there is a district of the Cadent and Vergent strata nearly 3 miles wide, being the region S. and W. of the Three Springs. The two edges of this approach, as we pass S.W., form a triangular area. About 8 miles S.W. of the end of Jack's Mountain, and 1 or 2 miles N.E. of the State road, and 1½ miles S.E. of the base of Sideling Hill, the Cadent and Vergent rocks disappear in a narrow point under the Ponent strata along the prolonged anticlinal axis of Jack's Mountain. This country, occupied by the Cadent and Vergent rocks, is uninteresting, and thinly settled. It forms parts of Springfield Township, Huntingdon County, and Dublin Township, Bedford County. The ridges are formed without any regularity, with the exception of Clear Ridge, which ranges S.W. from Hare's Valley, and is composed of the Vergent shales.

Cadent and Vergent Rocks along the S.E. Side of Great Aughwick Valley.—That belt of the Cadent and Vergent strata which occupies the S.E. side of Great Aughwick Valley, dips uniformly and steeply N.W. Its S.E. limit is near the base of Blacklog Mountain, and its general width is about 1¼ miles. Great

Aughwick Creek flows in it from its junction with Sideling Hill Creek, and the belt ranges from its point of separation from the preceding, near the junction of Three Spring Creek and Great Aughwick, for 10 or 11 miles S.W., in a straight direction, until it is united over the prolonged anticlinal axis of Blacklog Valley with the corresponding zone lying to the S.E. of that axis. This junction takes place in Fulton County, 2½ miles S.W. of Fort Littleton, and about 3 miles S.W. of the extremity of Blacklog Mountain. It occupies that part of Springfield Township, Huntingdon County, which lies immediately N.W. of Blacklog Mountain, and part of Dublin Township, Fulton County, to the N.W. of the ridge of Meridian sandstone, which is seen N.W. of Fort Littleton. But little iron ore has been discovered, although the strata in which it usually occurs crop out; but a closer search for it might be warranted, as we were informed that it had been found S.W. of Madden's Mill.

Cadent and Vergent Rocks—Synclinal Trough—Anticlinal Axes of Blacklog Valley and M^cConnellsburg Cove.—The Cadent and Vergent strata occupy a district 1¾ miles wide, immediately N.W. of Little Scrub Ridge, its N.W. limit being a line parallel to that ridge passing one-third of a mile S.E. of Littleton. It is in the form of a synclinal axis, of which the strata on the S.E. side, or nearer to Scrub Ridge, are perpendicular or overtilted, so as to dip 80° N.E., while those on the N.W. dip 30° S.E. With these dips it stretches, from the point S.E. of the end of Blacklog Mountain, for 4 or 5 miles S.W., when the Ponent red rocks begin to appear in the centre, dividing the Cadent and Vergent zone into two. Of these the N.W., dipping 30° S.E., is immediately united over the axis of Blacklog Valley, 3 miles S.W. of the Blacklog Mountain, with the North-west-dipping strata, which have been previously described, and there ranges thence a wide anticlinal tract for several miles, held up by the axis of Blacklog Valley.

Cadent and Vergent Rocks—Prolongation of the Anticlinal Axis of Blacklog Valley.—This zone forms a district averaging 3 miles in width, which stretches for 16 miles S.W. through parts of Dublin, Belfast, and Bethel townships, Bedford County. In connection with the subsiding of the anticlinal axes of Jack's Mountain and of Blacklog Valley, and the rising of that of Pigeon Cove, nearly in a line with the former, the whole broad Cadent and Vergent belt makes a sweep opposite Little Scrub Ridge towards the W., but in about 7 or 8 miles it assumes its original bearing, which is about S. 30° W. By this bend it attains the central part of the valley lying between Sideling Hill and Big Scrub Ridge.

Where the Pittsburg Turnpike crosses the belt, it is nearly 3 miles broad; its S.E. edge is 1½ miles from Big Scrub Ridge, and its N.W. about the same distance from Sideling Hill. Traced S.W. for 11 miles, it holds the same relation until the inferior formations are lifted by the anticlinal axis of Pigeon Cove, and the belt separates into two monoclinal ones.

Belt N.W. of Pigeon Cove.—This N.W. belt of the two is about 1¼ miles wide; its N.W. limit being 1¼ miles from the base of Sideling Hill and parallel to it, and its S.E. edge at the base of the N.W. Conoloway Ridge. It ranges thus across the State line. The dip is steep, and the surface, as usual with these groups of rocks, is irregular, and thinly inhabited.

Belt S.E. of Pigeon Cove.—The belt to the S.E. of Pigeon Cove is 1½ miles wide, its N.W. limit is at the S.E. base of the S.E. Conoloway Ridge. The general dip of its rocks is 40° S.E. Conoloway Creek flows along it, emptying into the Potomac near the boundary of the Vergent and Ponent strata. Hancock stands on the same belt near its N.W. border, and on the S.E. it is limited by the Ponent red sandstone.

The Cadent and Vergent rocks, thus traced, form extensive districts in Fulton County, which are very barren of mineral products, and offer little inducement to cultivation. The surface is very irregular, and the topographical features cannot be generalised, except by stating that ridges of the Vergent shales lie along the border next the Ponent strata. No iron ore is to be seen in the Cadent black slate in the position in which it occurs in Huntingdon and Mifflin counties, but it is by no means a settled point that it does not exist in the tracts described.

Cadent and Vergent Rocks—Belt N.W. of M^cConnellsburg Cove.—The synclinal tract of Cadent and Vergent strata N.W. of Little Scrub Ridge, was described as separating into two divisions by the introduction of a zone of Ponent rocks. The S.E. belt, the continuation of the rocks of the S.E. side of the synclinal basin of Little Aughwick Valley, ranges at the base of Little Scrub Ridge. Harshey's Mill is near the separation.

Traced S.W., its S.E. limit is in the slope of Scrub Ridge. The rocks are overtilted, dipping 80° S.E., and from their steep dip the belt is narrow. (See Fig. 53.) Between 2 and 3 miles S.W. from Harshey's Mill, its inferior strata begin to disappear in the fault; those which remain still preserving a dip of 80° S.E. By this successive disappearance of inferior strata, the belt narrows, so that opposite McConnellsburg it is only 500 yards wide. From the point in the fault where the Surgent, Pre-meridian, and Meridian strata vanish, S.W. to the end of Little Scrub Ridge, the strata of the Levant white sandstone in the ridges are in contact with the Vergent shales. (See Fig. 54.)

From the S.W. extremity of Little Scrub Ridge to Hunter's Mill, a distance of 6 miles, these Cadent and Vergent strata range in contact with the Matinal limestone, preserving their dip of 80° S.E. The belt is 800 yards wide, growing wider as it begins to emerge, until, at Hunter's Mill, the entire Cadent and Vergent strata are again at the surface. Their N.W. limit is about two-thirds of a mile S.E. of Big Scrub Ridge, and ranges parallel with it; they therefore form the hills which bound the N.W. side of the Cove in that part of it.

From Hunter's Mill S.W. we follow the same belt, which ranges in a nearly straight direction, until it is crossed by the State line: the rocks preserve an almost perpendicular dip, and the belt is consequently narrow.

Its S.E. limit is on the flank of Lowrey's Knob, and, traced S.W., passes a few hundred yards S.E. of Hanover Ironworks, at the base of Dickey's Mountain, along which it continues holding the same relation. Towards the termination of Dickey's Mountain the belt is a little curved, and forms part of the extreme W. corner of Franklin County, becoming somewhat wider. Coming from the Little Cove, it unites with the same formation over the Great Cove anticlinal axis in Maryland.

Little Cove (Franklin County).—These strata preserve their usual characters in the Little Cove. The iron ore found in the black slate in Huntingdon and Mifflin counties, exists in the Little Cove under precisely the same relations, though rather further from the Meridian sandstone, being nearly 100 feet above it.

The ore for Warren Furnace, which is of this variety, will be mentioned more particularly in the Chapter on ores.

Between 6 and 7 miles S.W. of the Mercersburg Turnpike, and 3 or 4 miles N.E. of Warren Ironworks, the Cadent black slate begins in the synclinal axis of Little Cove. For one or two miles it is narrow, and lies in the S.E. side of the Cove, S.E. of Little Cove Creek. Traced S.W., the whole Cadent and Vergent belt widens, so that where crossed by the State line it is $1\frac{1}{4}$ miles broad. The South-east-dipping strata dip at an angle of 30°, and those on the other side of the synclinal line are perpendicular, and in some places overtilted. Towards the State line, hills of some height, consisting of the harder strata, occupy the centre of the belt. Warren Ironworks are near the middle of the tract, where it is one mile wide, and the iron ore forms two ranges, one on each side of the basin. No loose ore was seen on the S.E. side, but specimens are abundant on the surface towards the N.E., where the belt is narrow.

The Warren Ore Banks are on the N.W. side, where the dip is comparatively gentle.

CHAPTER IX.

PONENT AND VESPERTINE ROCKS OF THE BELT.

Ponent Red Sandstone of Great Aughwick Valley.—The Ponent red sandstone first appears in the synclinal basin of Great Aughwick Valley, S.W. of the junction of Three Spring Creek with Aughwick Creek. Traced thence S.W., the zone grows gradually wider, with a regular synclinal position of the rocks, which dip 40° S.E. and 40° N.W. Where Sideling Hill Creek crosses it, the belt is about $1\frac{1}{4}$ miles wide, lying in Springfield Township. About 11 miles from the N.E. extremity of the belt, and $8\frac{1}{2}$ miles S.W. of the end of Jack's Mountain, the South-east-dipping strata unite over the prolonged anticlinal axis of Jack's Mountain with the corresponding strata which traverse Hare's Valley and the flank of Sideling Hill. This latter zone, traced S.W. from the mouth of Hare's Valley, forms the S.E. flank of Sideling Hill, and its S.E. limit is about $1\frac{1}{4}$ miles from the base of that mountain. The continuation of Clear Ridge of Hare's Valley indicates the position of this boundary. The dip where Sideling Hill Creek crosses the tract is 40° N.W.

Beyond the junction of the two belts over the axis of Jack's Mountain, the Ponent red sandstone forms a district, extending 3 miles S.E. of the base of Sideling Hill, and the rocks have three dips. This is the case on the State road from Littleton to Bedford. A short distance S.W. of this road, the anticlinal axis ends, and the dips then all assume a N.W. direction, at the same time that the S.E. limit of the formation rapidly approaches Sideling Hill. Thus on the Pittsburg Turnpike the belt is monoclinal, and occupies the flank of Sideling Hill, and a space only $1\frac{1}{4}$ miles wide at its base.

From the turnpike S.W. to the Maryland line, a distance of 21 miles, Sideling Hill ranges nearly straight, but it is cut by a number of notches or gaps. The S.E. limit of the formation extends parallel to the mountain, and one mile or more from its base, the dip being generally steep, and always to the N.W.

The Ponent red sandstone forms the S.E. flank of Sideling Hill, ascending at least two-thirds of its height. Much yellowish buff sandstone and shale prevail in the upper part: the lower portion of the formation is denuded into irregular ridges, and their soil is generally rather inferior, though somewhat better than that of the Cadent and Vergent strata, and more cultivated.

Ponent Rocks, Synclinal Basin between the Axes of Blacklog Valley and Pigeon Cove on the N.W., and M'Connellsburg Cove on the S.E.—The Ponent red sandstone first appears in this synclinal tract $2\frac{1}{2}$ miles S.W. of Littleton, and one mile N.W. of Harshey's Mill.

Traced S.W., it spreads out rapidly. The rocks on the N.W. dip 30° S.E., and those on the S.E. of the synclinal line are overtilted, dipping 80° S.E. It is divided 5 miles S.W. of the N.E. extremity of this zone by the curious basin of Big Scrub Ridge; and the belt on the N.W. side of this ridge forms its flank, and extends $1\frac{1}{2}$ miles N.W. of its base. Patterson's Run and Licking Creek flow upon it. The rock dips 30° S.E. About $6\frac{1}{2}$ miles from the N.W. extremity of Big Scrub Ridge, the Ponent conglomerate terminates in a knob.

Big Scrub Ridge.—The Ponent red sandstone on the S.E. side of this ridge forms its flank, and extends two-thirds of a mile from its base. The lower strata are overturned, dipping 80° S.E.; but as we approach the base of the ridge, the dip gradually changes to 80° N.W. (See Section.) The portion of the formation remotest from the base of the ridge is cut into irregular uncultivated hills.

The S.E. limit is but a few hundred yards N.W. of the line of the Little Scrub Ridge Fault; but towards Hunter's Mill it recedes as the Cadent and Vergent strata emerge from the fault. The point where the Ponent conglomerate ends in the S.W. part of Big Scrub Ridge is a little S.W. of the gap, N.W. of Hunter's Mill, through which Tumbling Run, the draining stream of the Meadow Grounds, passes. But Big Scrub Ridge extends several miles further S.W., being formed of the upper portion of the Ponent red sandstone.

Thus, then, a section S.W. of the extremity of the Ponent conglomerate shows a synclinal axis of the Ponent formation, the upper or central portion constituting the prolongation of Big Scrub Ridge, while the N.W. limit of the belt here is the S. flank of Timber Ridge N.W. of Licking Creek, and the S.E. limit is a line parallel to and about one mile N.W. of Dickey's Mountain. The distance between the two borders is $2\frac{3}{4}$ miles. Here the strata on the N.W. side dip 30° S.E., and those on the S.E. are perpendicular.

Traced further S.W., Big Scrub Ridge gradually declines, and terminates 1 or 2 miles W. of the Hanover Ironworks. Still further S.W., the junction of Cove and Licking Creeks is exactly on the line of the synclinal axis, N.W. of which the Ponent red rocks dip 35° S.E. over a breadth of about $1\frac{1}{4}$ miles, while to the S.E. of the same point they dip 70° N.W. across a breadth of three-fourths of a mile, the whole belt here being 2 miles wide. From this point S.W. for 5 or 6 miles to the State line, this basin of the Ponent rocks extends in a straight direction through Bethel Township, preserving the same width and the same dips. The N.W. limit on the Potomac is $1\frac{1}{4}$ miles below Hancock.

The surface of the formation, though rather elevated, is less hilly and more cultivated than is usual with these strata.

Vespertine Conglomerate, Big Scrub Ridge.—Big Scrub Ridge has a synclinal structure from its N.E. extremity, where the Pittsburg Turnpike crosses it for $6\frac{1}{2}$ miles S.W. The Vespertine conglomerate forms its crests. It is between 500 and 600 feet high, and has on its summit a curious little valley called the Meadow Grounds, composed of the Umbral red shale. The level of this valley is 200 or 300 feet below the mountain-crests on each side of it. Its surface descends towards the S.W., where the stream draining it passes through a narrow gorge in the S.E. side of the ridge, and the valley terminates. About 2 miles S.W. of its extremity the conglomerate itself ceases, but the ridge still extends for several miles, having a single synclinal crest of the upper members of the Ponent red sandstone.

The thickness of the conglomerate here is probably between 600 and 700 feet at the least. Its characters could not be examined in detail for want of a good exposure. Some of the beds are hard and compact quartzose conglomerate, possibly not altogether unsuitable for millstones. The lower beds form a series of precipices along the N.W flank of Big Scrub Ridge near its crest. In a fissure in one of these cliffs some handsome specimens of iron ore were found. The conglomerate on the N.W. side of the ridge dips uniformly 30° S.E., forming the crest N.W. of the Meadow Grounds.

On the S.E. side it outcrops at an angle of 80° N.W., and forms the crest S.E. of the Meadow Grounds. (See Fig. 30.) The two crests are about one mile apart where the mountain is broadest.

Umbral Red Shale, Big Scrub Ridge.—This rock forms, in the Meadow Grounds on the top of Big Scrub Ridge, a belt 500 to 600 yards wide, and about 5 miles in length, becoming narrower towards each extremity. The strata dip 80° N.W., and 30° S.E. The red shale produces a red soil, and the formation is degraded to a lower level than the surrounding ridges of the conglomerate. The surface is for the most part covered with transported materials, and is not cultivated, much of it being wild meadow-land.

CHAPTER X.

IRON ORES OF THE DISTRICT.

THE ores chiefly used by the furnaces of this region are those of the Surgent, Cadent, and Vergent formations. These, though rich, do not yield nearly so large a proportion of metal as the hæmatitic ores of the Matinal and Primal formations. They are more difficult to fuse, and rarely produce bar iron of the best quality. Where they alone are accessible, the smelting business is somewhat precarious, and requires great economy.

The Surgent block ore of the iron sandstone of the Tuscarora Mountain at Millerstown has been mined on the E. side of the Juniata, and Governor D. R. Porter has used it in his furnace at Harrisburg to mix with his hæmatitic ores.

Surgent Fossiliferous Ore, Huntingdon and Mifflin Counties.—This has been shown to overlie a stratum of sandstone in the valley S.E. of Jack's Mountain, and its several outcrops have been traced with some minuteness. It only remains to mention more particularly the points where, at the periods of our observations—namely, in 1842 and 1852—it had been developed.

At Matilda Furnace, Huntingdon County, the bed of Surgent fossiliferous ore consists in some places of two thin layers. It lies on the S.E. flank of a narrow sharp ridge, formed by the outcrop of the ore sandstone, which dips 22° S.E. The lower layer is 8 inches thick, and rests on sandstone, and in some localities it contains much sand, rendering it unprofitable.

In some early experiments made with this variety, six tons produced only one ton of metal, and required 600 bushels of charcoal. Its general appearance is like that of the more productive ore, having the same fossils; but a close examination shows it to contain a seriously large quantity of sand. About 4 inches of olive shale separate it from the upper layer, which is 10 inches thick, and of uniform composition. This has all the characters of the Surgent ore of Montour Ridge and other belts. At its outcrop it is porous and rich, the calcareous matter having, as usual, been removed by solution; but deeper down it is hard, and contains much carbonate of lime, which effervesces with acids. Two and a half tons of the soft ore yield one ton of pure metal.

Fossiliferous Ore of Hope Furnace, Mifflin County.—In Ferguson Valley, the fossiliferous ore developed by the first anticlinal axis has long been opened on the road from Hope Furnace to Greenwood. This has been described in tracing the Surgent strata in that valley.

The same species of ore has been mined on the N.W. side of the fifth anticlinal axis, a few hundred yards S.E. of Stroud's Mill. There are two layers, each 2 or 3 inches thick, separated by an equal thickness of olive slate. The bed dips 25° N.W. It is of the hard variety. About 10 feet below the true ore bed, there are in the sandstone several thin layers of a reddish colour, which have been dug into as ore, though they are merely highly ferruginous sandstones.

One mile or more S.W. of Stroud's Mill, on the summit of a ridge of the ore sandstone, on the fifth anticlinal axis, the fossiliferous ore was, and perhaps is, procured for Hope Furnace. It varies in thickness from 3 to 6 inches, and is of the soft variety. It is nearly horizontal, and is covered by about 2 feet of clay.

The fossiliferous ore is exposed at a place called Wakefield's Rock, 3 miles below Waynesburg, where the river and canal pass through the ridge on the fifth anticlinal axis. It is on the canal on the N. side of the anticlinal axis. The ore consists of two layers, each 2 inches thick. It is of the hard variety, and therefore calcareous. The dip is 21° N.W.

Near Wakefield's Mill, at the mouth of Brightfield's Run, on the canal, the fossiliferous ore is exposed, dipping 20° S.E., being on the S.E. side of the fifth anticlinal axis. It is here in two layers, each of 3 inches thickness, separated by 4 inches of reddish slate. This ore is of the hard variety.

Worral's Ore Bank.—This is on the S.E. side of the ridge of the fifth anticlinal axis, one mile or more S.W. of the ravine of Brightfield's Run. There is one layer from 3 to 5 inches thick; it rests on the ore sandstone. Near the surface it is weathered, and therefore rich, but deeper in it is hard and calcareous. This ore was used at Hope Furnace. It dips 15° S.E. Except the openings I have mentioned, there were none worthy of particular notice at the date of our examination of the district.

Surgent Cellular Ore of Hanover Furnace.—On the S.W. side of Dickey's Mountain, half a mile S.E. of the Lower Hanover Forge, a different iron ore is found. The best specimens are in masses, with angular cells often filled with clay. The walls of these cells are of a dark brown colour, being an argillaceous oxide of iron. Their surface is somewhat coated with crystalline brown iron-ore. The resemblance of this ore to that of the Cadent black slate is striking, and it is highly probable that it has had a similar origin; its cells are, however, more irregular. The thickness of the bed is from 14 inches to 2 feet. It inclines with the slate in which it is imbedded at a steep angle. The slates are soft and clayey, and of a yellowish, bluish, and white colour. The position of the ore is a few feet below the Surgent red shale, and its outcrop is high on the mountain-slope. It is well adapted to the hot blast, but from the thinness of the stratum and its steep dip it is not very valuable.

At several points along the flank of Dickey's Mountain, specimens of the same variety of ore were observed in the same geological position, showing that the ore-bed ranges with the formation. Specimens were also seen on the flank the ridge which bounds the N.W. side of Little Cove.

Iron Ore of the Meridian Sandstone and Slate, Chestnut Ridge, Huntingdon County.—The Meridian sandstones in Chestnut Ridge consist of two members, the upper being a mass of soft coarse-grained sandstone, and the lower, which I have called the Meridian slates, a group of argillaceous rocks, generally of a dull buff hue when weathered. Just where these meet, a stratum of ore, sometimes 2 feet in thickness, is frequently found. It is an arenaceous variety of little value, and is probably a layer of the sandy shale highly impregnated with iron. It seems to have been derived from the oxide of iron of the sandstone above, which is white and porous, as if filtration had robbed it of its finer particles, and collected them on the more impermeable argillaceous stratum below it. This bed has been opened W. of Chester Furnace, where the ore is of a dark colour, and contains too large an amount of oxide of manganese. It will not readily smelt, and is comparatively valueless. It was likewise opened about one mile N.E of Chester Furnace, and there the ore was of a reddish brown colour, but quite sandy, and of no worth.

Iron Ore of the Cadent Lower Black Slate.—A general description has been given of this ore, its position and origin, and it only remains to offer a short account of the ore-banks which are now or have formerly been worked.

Brookland Furnace Bank.—N.E. of Atkinson's Mill the ore was formerly dug for the Brookland Furnace. It is situated on the Cadent black slates in the synclinal trough of the first and second anticlinal axes, towards its S.W.

extremity. The bank is not now used. The ore has all the characteristics which have been mentioned in the general description of the ore of the formation. Its position is on the side of a ravine. The iron made from it was not of a good quality.

Walter's Bank.—This ore-bank is half a mile W. of Brookland Furnace Bank. It is on that belt of the Cadent black slate which has been described as passing N.W. of Brookland Furnace. It is not mined at present. The ore is of the cellular and laminated variety, and is an argillaceous peroxide: the unaltered carbonate does not appear. It was used at Hope Furnace, and was found rather difficult to fuse. The situation of the bank is such that water oozes through it, and thus facilitates the decomposition of the original bed of carbonate of iron.

Creswell's Ore Bank.—This is $2\frac{1}{2}$ miles N.E. of Waynesburg, on that belt of the black slate which lies in the synclinal trough of the third and fourth anticlinal axes. By the degradation of the North-west-dipping or S.E. outcrop of the sandstone, a little terrace is formed on the S.E. flank of the ridge N.W. of the turnpike.

The ore has the usual characters, but is not now worked.

Mevey's Ore Bank.—This is in the Cadent black slate, in the synclinal trough between the sixth anticlinal axis and Blue Ridge, $1\frac{1}{2}$ miles or more S.E. of Newton Hamilton. It is on a ridge of Meridian sandstone, which outcrops on each side of it with steep dips. The ore is cellular and sometimes laminated, and has a hazel colour when broken, but the surfaces are of a bright ferruginous yellow tint. It was used at Brookland Furnace, being conveyed there in boats upon the canal.

Ore Banks of Chester Furnace.—These ores are situated in the belt of Cadent black slate which crops out along the base of Chestnut Ridge. It is probable that the ore can be found along the whole extent of this ridge near its N.W. base. It has been mined in several places for the use of the Chester Furnace. The bed has a dip of 30° S.E., and varies from 3 to 6 feet in thickness, and is therefore in rather an unfavourable position for mining, as it dips rapidly under the slate. Chestnut Ridge, S.W. of Chester Furnace, is in many places levelled, and only exists as a chain of knolls. Near the base of these the ore is often to be seen. Only a few feet of slate lie between it and the argillaceous limestone below.

There are three or four openings S.W. of the Furnace which are all in a similar position, and do not merit a separate description. All the ore which has been taken out is of the cellular and laminated varieties. The cells generally contain some clay. Deeper excavation would no doubt reach the solid bed of the unaltered carbonate of iron.

BOOK VI.

SIXTH OR UPPER JUNIATA DISTRICT, BEING THE NORTH-WESTERN HALF OF THE APPALACHIAN CHAIN BETWEEN THE SUSQUEHANNA AND MARYLAND.

Having developed the structure and mineral resources of the Lower Juniata District, I proceed to a similar description of the equally interesting North-western half of the Appalachian Chain west of the Susquehanna. It is bounded on the S.E. by Montour Ridge, Jack's Mountain, and Sideling Hill, and on the N.W. by the summit of the Alleghany Mountain. In the general sketch of this district already given, it was shown to consist of five well-marked regions, the most Eastern of which is that lying E. of the mountain-spurs of Union County, and N.W. of the North Branch of the Susquehanna: to this we will therefore first direct our attention.

DIVISION I.

FIRST BELT OF THE SIXTH DISTRICT, MONTOUR RIDGE, BUFFALO VALLEY, MUNCY HILLS, &c.

SUBDIVISIONS, BOUNDARIES.

If we generalise the features of this somewhat diversified tract, we shall find it to consist of two anticlinal and two synclinal zones, or subordinate belts. Of these the *First*, or most Southern, is an anticlinal belt, the axis of which is that of Montour Ridge. It extends from the Wapwallopen to Turtle Run, in Union County. The *Second* is the synclinal zone lying N. of the last, prolonged from the Western termination of the Wyoming Basin, and including the Mahanoy Ridge and the main S. trough of Buffalo Valley. The *Third* is the anticlinal belt embraced between Shickshinny and Alleghany mountains. It is prolonged past Milton into the anticlinal spurs of Union County. The *Fourth* is the synclinal zone of the Muncy Hills, and of Whitedeer Hole Valley.

CHAPTER I.

CHARACTER OF THE STRATA; THEIR LOCAL TYPE.

THE rocks of the general tract of country before us appertain to the Levant, Pre-meridian, Meridian, Cadent, Vergent, and Ponent series, the lowest strata being the upper beds of the Levant white sandstone just visible in the S. flank of Montour Ridge, at the Danville Narrows, but well exposed in all the anticlinal mountain-ridges of Union County, where it forms the undulating margin of the region.

Levant, Surgent, and Scalent Series.—Examining, in the first place, the character of the Levant and Surgent formations, as they are developed in this tract, I shall present them under the local type which they possess in Montour Ridge, where they have been carefully measured and examined. They vary but little in other localities from the features and dimensions which they there present, and therefore the details now to be submitted will sufficiently represent the several members of the series, even in Buffalo and Whitedeer Hole valleys. A still better key, however, to the Levant, Surgent, and Pre-meridian rocks of this latter locality, will be found in the Section representing the strata of the fifth great belt of our General District, compiled on the West Branch, between Jersey Shore and Muncy. The Section exhibiting the strata under their N.E. type in the Appalachian middle zone will show the formations as seen in the vicinity of Danville. The Surgent series presents the following characters in Montour Ridge:—

SECTION OF THE SURGENT STRATA NEAR DANVILLE, DESCENDING.

Surgent Red Shale.

1. Of very uniform colour and composition, but including a very few thin green layers; *no fossils discovered,* . . . . 380 feet.
2. Alternations of red and green shale, ... 60 „

Surgent Upper Calcareous Shales.

Sandy argillaceous green fissile slates, often highly fossiliferous, alternating with layers of fossiliferous limestoue from 1 to 12 inches thick, ... 160 „

Fossils—Beyrichia, Atrypa, Avicula, Strophomenæ, Euomphalus, Encrini, Favosites, &c.

Thin band of pure ore.

Surgent Ore-Sandstone.

A tough calcareous sandstone alternating with thin bands of shale, . . . 8 „

Surgent Lower Calcareous Shales.

Green fissile slate, with thin plates of limestone, and eight or nine thicker limestone bands, all fossiliferous, ... 60 „

Fossil ore band, 25 feet from bottom, ... 1 ft. 4 in.

Surgent Upper Slate.

Green fissile slate with thin plates of argillaceous sandstone, . . . 50 feet.

Surgent Iron-Sandstone, ... 58 „

With its ferruginous band, ... 1 ft. 4 in.

Surgent Lower Slate.

Green slate, weathering yellow, generally sandy, often compact, not fissile. Its ore lies about midway in the mass, ... 700 feet.

Clinton fucoid, or *Buthotrephis gracilis* throughout.

Surgent Lower Slate, Montour Ridge.—This division of the series, the lowest formation usually exposed to view in Montour Ridge, where it appears arching over the summit of the ridge along a course of many miles, retains here its usual type, which is that of a greenish slate, changed at its outcrop to a yellow hue. It is generally rather sandy, is often compact, and is less fissile than the slate above the iron sandstone. Its thickness in Montour Ridge is about 700 feet. It includes one or two important thin layers of very ferruginous sandstone, rich enough, in certain localities, in the oxide of iron to fit it for making iron. The position of this ore is between 350 and 400 feet below the top of the formation.

Surgent Iron Sandstone.—In Montour Ridge the Surgent iron sandstone consists of ponderous red ferruginous sandstone, red argillaceous sandstone, and green sandy slate. It is generally triple, the middle member being chiefly composed of slate, and the upper and lower of the sandstone. It varies somewhat in its thickness, chiefly from changes in the dimensions of the sandstone strata, which increase from Danville E. At Danville the thickness of the formation is 58 feet. The lower red sandstone stratum contains two or three layers of dark brown heavy rock, in some localities rich enough in the oxide of iron to constitute an excellent auxiliary ore in the blast-furnace. In no locality has this massive hard ore been discovered of such value and thickness as at Danville. The middle member of the formation consists of an alternation of beds of green and yellow sandy slates, with thinner beds of the brown sandstone. The outcrop of the iron sandstone, occupying a low ragged ridge on each side of Montour Ridge, affords an excellent index to the position of the iron ore.

Surgent Upper Strata.—This is a green fissile slate, embracing thin layers of red argillaceous sandstone and red shale. It is a much thinner stratum than the Surgent older slate, being at Danville not more than 50 feet thick. The only organic form which characterises this rock is the small fossil marine plant, the *Buthotrephis gracilis*, found likewise in the lower slate. Like the Surgent iron sandstone, this Surgent upper stratum augments in thickness in its course Eastward, being essentially thicker on Fishing Creek than on the Mahoning.

Surgent Lower Calcareous Shale.—In the belt before us this member of the series possesses very nearly the composition which belongs to it in the Lewistown Valley, and at Mifflintown. At Danville it is about 60 feet thick, but its slates being nearly identical in character with those of the Surgent upper slate, the line of separation is not very distinctly marked. The chief body of the formation is, however, readily recognised by its numerous fossils and calcareous layers. The whole mass may be described as composed of greenish and olive-coloured fissile slate, imbedding thin layers of very fossiliferous grey limestone, eight or nine of which are each only a few inches thick. About 25 feet above the bottom of the formation occurs at Danville the main *fossiliferous ore-bed.* It is merely a band of fossiliferous limestone, more largely impregnated than the rest with the peroxide of iron. Its thickness along the S. slope of the ridge is from 14 to 18 or 20 inches. The fossils of this and the Surgent newer ore shale are almost identical. One of the most abundant is the *Beyrichia pisiformis.* (See the *general* description of the formations.)

Surgent Ore-Sandstone.—This is a tough grey-and-yellowish sandstone, containing Encrini and a few other fossils, and some calcareous matter. Its beds are divided by thin seams of calcareous shale. Throughout the belt of Montour Ridge it is very thin, measuring at the Danville Narrows not more than 8 feet.

Surgent Upper Calcareous Shale.—This upper formation of the Surgent calcareous shale group consists of an alternation of sandy and argillaceous green fissile slates and soft shales, with thinner beds of fossiliferous limestone, the latter varying in thickness from one inch to one foot. Both the shales and the limestone abound in the characteristic fossils of the ore group. The total thickness of this formation in the vicinity of Danville is about 160 feet, but it increases gradually W., and is about 200 feet in Buffalo Valley. A comparison of this section with that of the N.W. or Muncy belt shows that the formation now referred to, augments to 230 feet in crossing the region from Montour Ridge to that line. It also indicates the ore sandstone to have thinned away in that direction. At Danville the calcareous layers of the Surgent upper shale are sufficiently numerous and contiguous to each other in one belt near the furnaces, to have led to their being quarried for limestone, and employed at one time as a flux for the ore. This limestone has not, however, been found sufficiently pure ; it contains too large a proportion of argillaceous matter, and is, moreover, somewhat magnesian. The subdivisions which these Surgent upper shales assume at Danville, are shown in the expanded vertical section (see Fig. for that locality). It will be seen that the lower member consists of an alternation of shale and slate with beds of ferruginous limestone. These latter are the representatives of the fossiliferous iron-ore of certain localities. At the Danville Narrows, where they are well exposed, they are not replete enough in the oxide of iron, nor have they undergone the requisite solution by surface-waters to be of any economical value as beds of ore.

Surgent Red Shale or Red Marl.—The Surgent red shale of the base of Montour Ridge, and of Buffalo and Whitedeer Hole valleys, preserves its well-marked typical characters with very little local variation, being everywhere a brownish red shale, slightly calcareous, and somewhat sandy. Its thickness is very constant, being about 380 feet. In Montour Ridge, the first or lowest 60 feet consist of an alternation of red and greenish shale, the latter variety being relatively small in quantity. The formation passes upwards into the

Scalent Variegated Marls.—This division of the series is apparently of very subordinate thickness in the tract of country N. of Montour Ridge, but increases as we go W. into Buffalo Valley. It would seem to be a law of the formation to vary much in its dimensions, as already shown in the description of the Scalent marls of Lewistown Valley.

Scalent Grey Marls.—This is much the thickest subdivision of the Scalent series in the middle belts of the Appalachian Chain. In our Eastern or Susquehanna division of the sixth district, it is admirably exposed on the W. bank of the river below Milton, where the entire thickness of the two formations (the grey and the variegated marls) is about 1500 feet. Assigning 200 feet or thereabouts for the variegated marls, the dimensions of which have not been very accurately determined, the thickness of the grey marl cannot be less than 1300 feet. The formation has very nearly the composition which it exhibits in the Lewistown Valley. It consists of grey, bluish, and greenish marls, including occasional bands of purple-coloured slate and beds of flaggy argillaceous limestone. Some of these limestone strata are 20 or 30 feet thick. The upper part of the formation is composed near Muncy of blue shales, alternating with black fissile carbonaceous slate and thin layers of limestone; this subdivision being not less than 200 feet in thickness. These marls furnish an admirable soil, which derives its fertility from the calcareous matter they incessantly supply by their disintegration. Their great thickness, and the gentle angles at which they outcrop, cause them to overspread large tracts, both in Buffalo Valley and the country E. of the Susquehanna around Milton, where abundant harvests denote their presence.

Scalent Limestone.—It is not easy to determine with precision the lower limit of the Scalent limestone, from the circumstance of its occurring usually at the foot of the limestone ridges of the region; hence the full thickness of this formation is seldom seen. Near the end of the White-deer Mountain at the river, also in Dale's Hill and Limestone Ridge in Buffalo Valley, and again on Fishing Creek near Bloomsburg, we meet with distinct exhibitions of all but the lower portion of the stratum. It has everywhere the character of a thin-bedded or flaggy blue limestone, argillaceous in the lower part, and more purely calcareous and massive in the upper. In respect to thickness, the formation varies from 100 to 150 feet, the mass gradually augmenting as we trace it towards its more N.W. outcrops. It may be everywhere distinguished from the Pre-meridian limestone, which, when present, directly overlies it, by its containing the *Cytherina alta*, and one or two other characteristic Scalent fossils.

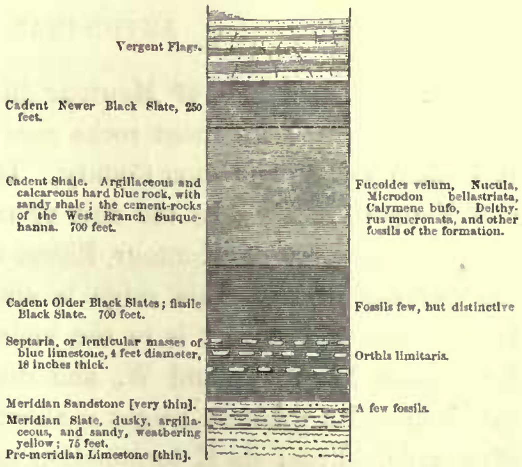
Pre-meridian and Meridian Series.—In the belt of country before us the Pre-meridian and Meridian series are less fully developed than in the region further to the S.W. All three of their constituent formations are met with, and in some places associated, though more frequently one or other stratum is absent, or is so thin as to elude discovery.

Pre-meridian Limestone.—This formation usually exhibits itself in the belt I am describing, under one type, that of a massive fossiliferous blue limestone. It generally contains one or more layers of grey chert, especially near its upper limit. The presence of numerous corals—the *Catenipora escharoides*, *Favosites*, *Cyathophyllum*, &c., and a profusion of fragments of Encrini—imparts to the rock a knotty aspect and irregular fracture, and serves readily to distinguish it from the almost non-fossiliferous Scalent limestone. It has seldom the thickness of this last-named stratum, nor is it as constant in its dimensions. Along the base of Montour Ridge it has a thickness near Bloomsburg of 60 feet, but in the prolongation of the belt N.E. this decreases, and at the quarries near Harman's, 6 miles W. of Berwick, it is greatly thinned down. Traced in the opposite direction, it seems steadily to enlarge, for after crossing the W. branch of the Susquehanna, it appears in a ridge about 2½ miles N. of Lewisburg, with a thickness of 140 or 150 feet. As we advance N.W. it seems again to decline in thickness.

Meridian Slates.—The middle formation of the Pre-meridian and Meridian series is apparently a more continuous stratum than either the limestone or the Meridian sandstone. In the double line of outcrop in which all these rocks encompass Montour Ridge, the Meridian slates seem to comprise two somewhat distinct members, which appear to prevail together throughout the region wherever the series is lifted to the surface. The lower division consists of soft black slate and dark ash-coloured shale, and the superior member of bluish sandy shale, having a buff colour at its outcrop. These upper sandy beds graduate into cherty sandstone and chert, and form the passage into the Meridian sandstone, containing a mixture of the fossils of the latter formation, and others peculiar to their own stratum. North of Montour Ridge, the formation occurs in the vicinity of Mooretown with an aggregate thickness of about 60 feet, the dark slates measuring nearly 25 feet, and the overlying sandy shales, or laminated shale sandstone and chert, about 35 feet. The whole mass has about the same thickness, and appears under similar characters on the W. side of the Susquehanna. A comparison of the stratum as it is thus developed N. of Montour Ridge, with the features it exhibits on the axis of the Tuscarora Mountains at the Susquehanna, discloses no very important variation in its type, unless it be in the augmentation of the lower dusky slate member. It is interesting to compare this formation as we behold it in the region before us, with its aspect at the Delaware Water-Gap in the one direction, and on the Upper Juniata in the other. At the Delaware River it wears almost precisely the features under which I have now described it as seen at Montour Ridge, but it is there from 200 to 250 feet thick, being by far the most important member of the series. As developed at Frankstown, it shows almost the same composition—dark slates below and grey sandy calcareous shales above, with an aggregate thickness of 170 feet. It would thus seem to be least expanded in the intermediate locality.

Meridian Sandstone.—Throughout the first division of the sixth district this easily-recognised rock is rarely to be seen, in consequence of its extreme reduction in thickness, and indeed its total absence from many localities where the other Pre-meridian or Meridian rocks appear. In the vicinity of Montour Ridge it would seem to be altogether wanting, for along the slender belt which passes near Mooretown, the Cadent lower black slate is in immediate contact with the Meridian slate. Nowhere in Buffalo Valley has any trace of this stratum been seen, only a few loose fragments being met with on the summits of the limestone ridges, whither they may have been transported from more N. outcrops. Further towards the N.W., in the outcrop which sweeps round the end of the anticlinal of the Bald Eagle Mountain, and passes near Muncy, we detect the formation, but it rarely surpasses the thickness of a very few feet. Its position will generally be indicated by the easily recognisable fragments of chert, a bed of which immediately adjoins it, separating it from the Pre-meridian slate. The absence of this not readily eroded rock is one cause of the smoothness of surface which belongs to much of the region N. and W. of Montour Ridge.

FIG. 80.—Strata of the Muncy Hills.



Cadent and Vergent Series.—The Cadent and Vergent rocks appear in the region under examination in three belts; one S. of Montour Ridge, one N. of it, and the third a zone prolonged from the valley of Harvey's Creek, and of Fishing Creek, through the Muncy Hills, into Whitedeer Hole Valley. They exist in only a very short and narrow tract on the W. side of the river N. of Lewisburg.

The *vertical section* here appended exhibits the type under which the three lower formations are developed in the belt of the Muncy Hills. The two upper formations of the series omitted in the above section, are conspicuous in each of the three belts before referred to, forming rather elevated ranges of hills. Such are the two lines of hills extending parallel with each flank of Montour Ridge. Where the N. Branch of the Susquehanna intersects the most S. of these belts above Danville, and again opposite Catawissa, admirable exhibitions are afforded of the two enormously thick formations, the Vergent flags and the Vergent shales. The precise thickness of the first of these has not been ascertained, for at no locality could the lower limit of the mass be discovered, this being always at the foot of a ridge, and buried under a covering of fragments and soil. I estimate the mass of the Vergent flags at not less than 1000 feet. They are characterised by the usual species of marine plants.

The Vergent shales were minutely studied and successfully measured between Catawissa and Bloomsburg. At this locality they consist of the ordinary alternation of grey, red, and olive-coloured sandy shales, and grey and red argillaceous sandstone, the reddish beds occurring only in the upper half of the formation, and the entire mass abounding in distinctive fossils. Its total thickness from the assumed base of the Ponent series—namely, the beginning of the continuous red strata, almost without fossils—to the Vergent flags is about 3150 feet.

Ponent Series.—The Ponent series forms three belts in this portion of our district, one N. of the anticlinal of Montour Ridge, one N. of the Shickshinny Mountain, and the third at the S. foot of the Alleghany Mountain. It exhibits little or no deviation in character from the very permanent type under which it has been already described in connection with the districts in the S.E. and S.W., and a special description will therefore be omitted. Opposite Catawissa it measures nearly 4200 feet in thickness, but it is considerably thinner where it outcrops at the base, and in the flank of the Alleghany Mountain. Having thus exhibited the features of composition belonging to the several formations which constitute the Susquehanna portion of our district, I shall pass on to the description of the four several zones or subordinate belts which it embraces.

CHAPTER II.

ANTICLINAL BELT OF MONTOUR RIDGE.

THE anticlinal belt of Montour Ridge is a long and ample flexure or wave in the strata, commencing in the Ponent rocks near the sources of the Wapwallopen, and terminating W. in Buffalo Valley, in Union County. It comprises the Levant, Pre-meridian, Meridian, Cadent, and Vergent rocks. In the axis or medial line of this enormous wave rises the beautifully symmetrical crest of Montour Ridge, overarched by the middle or iron-bearing members of the Surgent series. This ridge is almost perfectly straight, and of very regular form. Its highest and widest part is in the vicinity of Danville, but it maintains a nearly level summit for a great length E. and W., and declines at each extremity in a long gradual slope into the plain. Its greatest height is about 600 feet, and its mean breadth perhaps three-fourths of a mile. From its E. termination near Espytown to its W. at the Susquehanna, 4 miles N. of Northumberland, the whole length of the crest is very nearly 27 miles. A low valley, generally less than half a mile in width, lies immediately at the foot of the mountain, bounding it on each side, as it were, by a broad fosse. Each of these vales is excavated in a belt of the soft Scalent marls, Pre-meridian, Meridian, and Cadent strata, and outside of each is a broad continuous undulating range of monoclinal hills forming their outer boundary, and encircling Montour Ridge in the form of a low broken rampart. These two zones of hills consist of the thick and resisting formations of the Vergent flags and the Vergent shales, each belt of strata dipping from the axis of the general anticlinal wave. They close together beyond the termination of Montour Ridge, and range thence as a single anticlinal tract of the series. That at the W. end of the Ridge passes but a short distance into Union County before it becomes lost in the wider synclinal basin of the Blue Hill belt, while that at the E. end ranges up the valley of the N. Branch and Wapwallopen, nearly to the head of this latter stream.

STRUCTURE AND CONTENTS OF MONTOUR RIDGE.

In describing Montour Ridge as a regular anticlinal wave in the strata, I would not convey the idea that it is perfectly symmetrical in its structure. It exhibits, on the contrary, important deviations from strict anticlinal symmetry. It is really constituted of two anticlinal crests not precisely in a line with each other, one N. of Bloomsburg declining toward the valley of Hemlock Creek, and the other, and by far the longest, rising near this stream on the S. flank of the first, and terminating near Northumberland. Where the two axes thus overlap, or, more correctly, where the two waves thus coalesce laterally near their extremities, the line of the E. crest is nearly one-fourth of a mile N. of that of the W. To this fortunate doubling of the flexure at Hemlock Creek is due the spreading out, at a shallow depth below the surface, of the fossiliferous ore, which is supported on the backs of two broad waves in place of one. The better to convey a clear conception of the structure of the ridge in the different portions of its length, I shall here introduce several sections (figs. 81, 82, 83), one illustrative of the main ridge at Danville, another of the double wave at Hemlock Creek, and a third of the Eastern Ridge at Fishing Creek.

FIG. 81.—Section of Montour Ridge at Danville.

FIG. 82.—Section of Montour Ridge at Hemlock Creek.

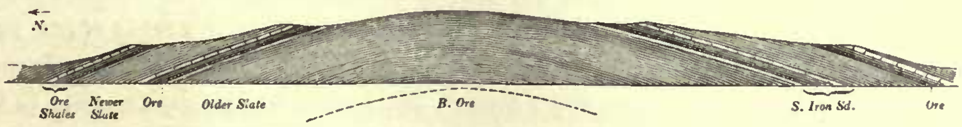
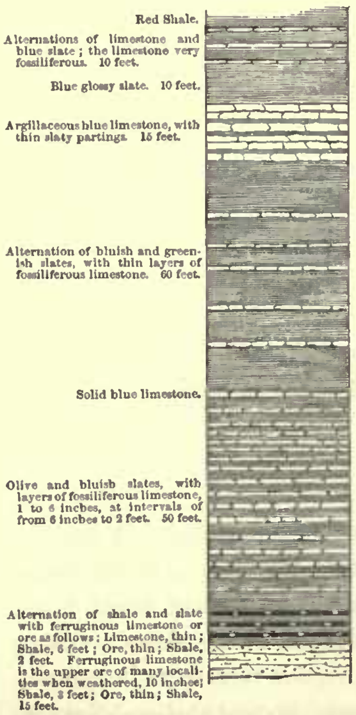


FIG. 83.—Section of Montour Ridge at Fishing Creek.

A glance at the first of these sections shows us that the flexure is not accurately symmetrical, but that the dip on the N. side of the axis is somewhat steeper than on the S., and that the wave, therefore, is of the normal form. One consequence of this greater inclination in the strata of the N. flank is a less length of breast in the ore-beds; but a still more important result is in the more rapid increase in the thickness of the slates overlying the fossiliferous ore, reducing the amount of the soft or infiltrated portion. This section represents the prevailing form of the ridge, and the situation of the several outcrops of the different formations and their subdivisions for a length of 5 or 6 miles both E. and W. of Danville.

Along this distance the summit of the mountain is formed of the Surgent older slates, which saddle it in a broad gentle arch. In some places the upper, in some the middle portions of this very thick formation, occupy the anticlinal crest, and in certain localities the two outcrops of the Iron-sandstone approach, so as almost to coalesce and overlap it. Throughout all this part of the range, each outcrop of the Iron-sandstone forms a shoulder on the slope of the mountain, between which and the foot of the central crest the declivity is comparatively gentle. The position of the Iron-sandstone is indicated to the eye, even at a distance, by a narrow belt of steep and stony ground, bordering the more gentle declivity of slate above it, and covered along its whole line by a skirt of woods, containing tall pines and other coniferous trees. It is on the higher portion of the mountain between these two outcrops of the Iron-sandstone that the *silicious iron-ore of the Surgent lower slate* appears upon the surface, usually in a double line of outcrop, the N. one about 800 or 900 feet S. of the N. line of the Iron-sandstone, and the S. one 800 or 900 feet N. of the Southern belt. If we commence a detailed examination of the ridge in the vicinity of the Danville Narrows, 2 miles W. of the town, where the strata possess the particular type shown in the vertical column introduced in the preceding chapter, and trace the rocks E. and W. from this point, we shall find that for 3 or 4 miles along this central and most uplifted portion of the anticlinal belt, where the top of the Levant white sandstone, though rarely seen, is elevated to the water-level, the whole crown of the ridge is overarched by the Surgent older slate, and the two outcrops of the Iron-sandstone are at their greatest distance from each other. Here, at the place called the Narrows, an extensive denudation of the S. flank of the mountain exposes the bottom layers of the older slate. In a deep crescent-shaped excavation, more than 2 miles in extent, the upper strata of the S. slope have been removed; and thus all the rocks, from the top of the Levant white sandstone to the top of the red marl or shale, are displayed in an oblique section. This excavation upon the side of the ridge has cut away, for the distance of 2 miles, the entire ore-bearing portion of the Surgent series above the river-level, and thus there is here an interruption in the outcrop of both the upper and lower calcareous ore shales containing the fossiliferous iron-ore, and also of the Iron-sandstone, the repository of the scarcely less valuable "hard ore." In this natural section of the ore-shales we have an opportunity for studying minutely the position of the layers of fossiliferous iron-ore. The Surgent Ore-sandstone, as represented in the column alluded to above, is distinctly seen in the form of a calcareous sandstone, only 7 or 8 feet thick, dividing the upper from the lower ore-shale. In the Upper Ore-shale we have a formation measuring in all about 160 feet, composed of an alternation of bluish and greenish calcareous slates, with argillaceous blue limestone in the upper portion, and thinner layers of blue compact fossiliferous limestone in the middle and lower. The lowest beds of this shale contain three or four bands of highly fossiliferous and ferruginous limestone; these are the equivalents of the fossiliferous iron-ore of some localities in the unaltered or undissolved state, but they do not represent the fossiliferous ore wrought along the flanks of Montour's Ridge, that bed appertaining, as our general column shows, to the Surgent lower calcareous shale. These layers are here too deficient in the oxide of iron to constitute a real ore. The dimensions and composition of the several component layers of the Surgent upper shale of this locality being fully described in the following section (fig. 84), any further details would seem to be superfluous.

FIG. 84.—Surgent Upper Calcareous Shales at Danville.



The true fossiliferous iron of Montour Ridge, and indeed of very many other of the outcrops of the Surgent series in the Appalachian districts of the State, is merely a more than usually ferruginous bed of similar fossiliferous limestone in the Surgent older shale, the place of which in the formation is seldom more than 30 or 40 feet below the bottom of the Ore-sandstone, the outcrop of which affords us thus an excellent clue to it. The older shale-formation being at the Danville, Narrows, and at Danville about 60 feet in thickness, the place of the fossiliferous ore is about 25 feet above its inferior limit. At the Narrows, the ore-bed contains too little oxide of iron, and has not been sufficiently acted on by surface-waters to be worth the operation of smelting it. It would appear that, Westward from this central locality of the Narrows of the Susquehanna, both the fossiliferous ore and the hard or block-ore of the Iron-sandstone are so much reduced in thickness, and in their proportion of oxide of iron, as to be, unless perhaps in a very few localities, quite valueless for economical purposes. I shall therefore confine my description of the structure and resources of the ridge to the more interesting part included between this point and its E. termination.

Iron Ores at Danville.—From the Narrows to the gap of Mahoning Creek at Danville, the length of outcrop of the two ores on the S. side of the mountain does not exceed about half a mile. That of the hard ore is considerably the longest, and as the Iron-sandstone containing it outcrops much higher on the ridge than the other ore, the quantity of this exposed above the water-level exceeds that of the latter many times. In this part of the ridge, the average length of the slope or breast of the Iron-sandstone ore, *above the water-level alone,* is probably more than 200 yards: that of the fossiliferous ore is materially less, while, for reasons already shown, the depth of breast of the soft and partially-decomposed ore may not average more than 30 or 40 yards. The position of the hard ore, in the vicinity of the gorge of the Mahoning, is shown in our transverse section of the ridge at that place. By inspecting the vertical section which I have introduced of the Iron-sandstone formation, analysed in detail, the reader will perceive that while the red sandstone members include two or three excessively ponderous layers, rich enough in iron to be applicable as iron ores, the thickest of these—the only bed, indeed, which is of sufficient magnitude to be wrought at the present day—accompanies the lower bed of sandstone, and has dimensions varying from 14 to 18 inches. But there is another formation here developed, in which beds of iron ore are discoverable. This is the Surgent older or lower slate, this stratum possessing in Montour Ridge a thickness of about 700 feet. Its ore has the form of a very ferruginous sandstone in one or two thin and continuous layers, occupying a horizon, near the middle of the formation, between 350 and 400 feet below its superior limit. Scarcely any difference is perceptible either in aspect or composition between the ore now referred to and that of the Iron-sandstone. It is a sandstone with a large proportion of peroxide of iron diffused among the particles, and, like the other bed, includes numerous small flat fragments, or pebbles of greenish slate, which by their disintegration leave the surfaces of the blocks, wherever the weather has had access, pitted with little elongated holes, forming one of the most distinctive features of these two ores. This ore-bed of the lower slate outcrops near the summit of the ridge on the E. side of the Mahoning Gap at Danville, arching the anticlinal axis at an elevation of about 300 feet above the bed of this transverse valley. Traced E. and W. from the Notch, the overlying slate saddles it, and conceals it from view wherever the mountain is low and narrow; but wherever the anticlinal rises—or wherever, in other words, the wave in the strata increases in breadth and height—the ore no longer closes over the axis, but forms two separate lines of outcrop, one on each gentle declivity between the summit and the shoulder, formed by the outcrop of the Iron-sandstone. In the vicinity of Danville, the thickness of this layer of ore is not such as to make it of much importance, so long as the thicker and therefore cheaper beds furnish an ample supply. Judging from the fragments at the point of outcrop, I infer its size to be between 6 and 8 inches. The facility and cost of mining it will of course depend upon several conditions connected with the dip and depth of covering, and will vary with each locality.

Our section of the strata at the Mahoning Gap represents the entire mass of the mountain as consisting there of the two Surgent slates and their included Iron-sandstone, while the calcareous or ore shales, with their fossiliferous ore, rest low at the N. and S. base. The upper beds of the Levant white sandstone have not been lifted to the level of the bed of the Notch, though their depth beneath it cannot be considerable. This proves a sinking of the axis from opposite the Narrows to this point; but when the ridge is examined still further E., it becomes apparent that between the Mahoning and Hemlock, the anticlinal rises and swells again, causing the hard ore of the slate to diverge into two outcrops, and the belts of the Iron-sandstone to recede. About halfway between those two streams is probably the neighbourhood in which the section of the mountain has its greatest expansion, and the two belts of the Iron-sandstone are furthest asunder.

Let us now, before advancing any further E., attempt an estimate of the quantity of iron ore above the water-level within a given length—say one mile of outcrop—in the vicinity of Danville.

I shall reject from my present calculation both the ore of the older slate and the compact unchanged fossiliferous ore; the former as being too thin and deeply covered to be profitably mined, and the latter as too poor in iron, and too calcareous, to be, under existing circumstances, adapted to the smelting furnace.

If we assume the soft fossiliferous ore of this neighbourhood to have an average thickness of from 16 to 18 inches, which is probably not far from the truth, we may consider each square yard of its surface to represent about one ton weight of ore. Let us now adopt the estimate I have already given of the depth to which the ore stratum has been converted into this soft ore, and accept 30 yards as the limit. Each yard of length along the outcrop will then be equivalent to 30 tons of the ore, and one mile of outcrop should supply about 52,800 tons. This amount, it will be understood, is irrespective of elevation above the water-level. Turning now to the hard or silicious ore of the Iron-sandstone, we shall find one mile of the outcrop-bed to offer a far more enormous quantity of available ore. It is obvious that the whole of the bed is convertible to use, since the composition of the ore is such as to make it fit for the furnace without its undergoing any solvent action, of which, indeed, it is scarcely susceptible. The only limit to the depth to which it may be profitably wrought, is the cost of mining it, and since this element is materially increased the moment we pass below the water-level of the locality, it will be expedient to restrict our present estimate to the quantity of the ore above this natural line. It has been stated that in the vicinity of the Mahoning Gap, the average length of slope or breast belonging to the Iron-sandstone is about 200 yards; on the S. side it is perhaps somewhat greater, while on the N. side it is probably as much less. This is equivalent to 200 tons of ore to each yard of the outcrop, the ore-bed being from 14 to 16 inches thick. One mile of length of outcrop will therefore yield 352,000 tons of the ore above the water-level. All that portion which is in this position is therefore nearly seven times as great as the similar part of the soft fossiliferous ore. The two ore-beds together represent more than 400,000 tons in a single mile of outcrop; but as, from the anticlinal form of the mountain, there is a double line of outcrop for each kind of ore, it is clear that one mile of length of the ridge must contain, upon the supposition of no deep ravines or notches intervening, the amazing quantity of 800,000 tons of ore. It is to be remarked that in the foregoing statement I exclude the consideration of the ravines, which interrupt at frequent intervals the general line of the outcrop of the strata, and reduce materially the amount of ore above the water-level.

An abatement of one-eighth from the quantity as above computed, on the supposition of a perfectly continuous outcrop, will probably more than compensate for the amount thus lost. With this reduction we shall still have, in one mile of the ridge, 700,000 tons of good ore.

The ore-estate attached to the Montour Ironworks of Danville, embraces, if I have been correctly informed, a total length of outcrop of the Iron-sandstone ore of 2200 yards, equivalent alone to 385,000 tons; the whole quantity of the soft fossiliferous ore I estimate at 45,000 tons; making the entire amount of ore available under existing circumstances 430,000 tons. Such is the apparently enormous extent of the mineral wealth of this favoured locality.*

Montour Ridge, between the Mahoning and Hemlock Creeks.—It has been shown that, the anticlinal rising again E. of the Danville Gap, the lower strata become more developed upon the summit of the mountain, and the two parallel belts of ore on its flanks are wider apart at their outcrops. In consequence of this feature, the outcrops of the Iron-sandstone do not lie as high on the slopes of the ridge as at Danville, where a little greater depression of the axis would have caused this formation to saddle the summit. The extent of breast, therefore, of the Iron-sandstone ore above the lowest attainable level of the adjacent valley, is materially less that at the notch of the Mahoning. To command, moreover, this amount of breast without a resort to machinery, it will be necessary, in all this part of the outcrop, to pierce each base or slope of the mountain with tunnels; a necessity which must lessen essentially the value of the ore, even if it should be found maintaining the richness and thickness which characterise it at Danville. But personal observation, and the testimony of others interested in the truth, have convinced me that this important ore, which constitutes, as we have seen, the main portion of the mineral wealth of the Danville locality, becomes much reduced in thickness, and impoverished in its amount of oxide of iron, within the distance of even 1½ miles E. of the Mahoning Gap. I have already stated that it declines in a

* This estimate of the amount of fossiliferous ore at Danville was made in 1846.

similar manner when traced W. Although the Iron-sandstone forms a complete girdle round this middle division of the chain, embracing each slope, and closing round its E. end on the W. side of Hemlock Creek, and although it is admirably well revealed to observation along both of its naked lines of outcrop, and at numerous little lateral valleys on the flanks of the mountain where its barrier is deeply breached, and the edges of the strata made visible, yet in no single locality between the two gaps has the hard ore belonging to it been as yet discovered of a quality to make it fit for smelting. In some places a bed is met with holding the usual position of the ore in the stratum, and approximating imperfectly to the true ore in aspect and composition, but in no instance has it proved to be valuable; it may, however, admit of being mined to a limited extent. These facts of the impoverishment of this ore, one of the most important beds of the entire belt, are calculated to lessen greatly our estimate of the resources of this extensive portion of the ridge, and to awaken in cautious and far-seeing minds grave apprehensions of the ultimate capacity of the district to sustain with an adequate supply of ore that very large mass of capital, which, judging from the investments of the past few years, and the scale of present enterprises, appears likely to be embarked here in the smelting and manufacture of iron.

The Iron-sandstone may be examined about 2½ miles E. of Danville on the S. side of the river, on a farm belonging to the Bloomsburg Iron Company, where it will be seen to possess very nearly its Danville type—having, that is to say, an upper sandstone, a middle stratum many feet thick of yellow slate, and beneath this a lower sandstone. This last stratum exposes its outcrop by the side of a road leading into the ridge, and shows in the usual position the hard or silicious iron-ore, the fragments of which, however, are all small, and indicative of a very inferior ore. Along the N. slope of the ridge, the ore is recognisable under almost precisely the same associations, but it is generally too poor in oxide of iron ever to warrant the cost of developing its outcrop. At the E. point of the main mountain, which terminates in a regular anticlinal slope at Hemlock Creek, the layer of sandstone corresponding to the iron ore has been mined in several spots by the Bloomsburg Iron Company, but hitherto it has disappointed anticipations in not containing a sufficiency of iron. This being the true condition of the main bed of the silicious ore, let us next inquire into the degree of richness attained by the similar band which is interstratified with the Surgent lower slate. I have already shown that from the influence of increased elevation in the whole anticlinal belt, and the denudation of the summit of the ridge, the same strata have not only a wider space in this position of the range than at the Mahoning Gap, but the N. and S. outcrops are further asunder. It is owing to these causes that the formation here spoken of occupies so broad a belt along the top of the mountain, and that the layer of silicious iron-ore occurring near the middle of the mass, in place of forming, as at the Mahoning, an almost unbroken anticlinal arch, is traceable in two separate lines of outcrop, one on each comparatively gentle slope, at the base of the central crest, and above the line of the Iron-sandstone. Such is the position of this iron ore, the whole distance from the vicinity of Danville to a point about 2½ or 3 miles W. of the termination of the ridge at Hemlock Creek. The two belts of ore, first gradually receding at their widest distance, range for 2 or 3 miles in nearly strict parallelism, then approach, and finally unite in a continuous arch upon the top of the ridge, and disappear beneath the mass of overlying slate. This junction of the two outcrops, and their final departure from the surface of the ore-bed, occurs perhaps half a mile or more E. of Bittenbender's Farm, upon which the N. outcrop of the ore has of late been experimentally mined by the Bloomsburg Iron Company. The fact already stated, that the usual surface-distance between the iron ore and the Iron-sandstone along the S. slope is about 800 or 900 feet, and on the N. about 700 or 800 feet, though a sufficient clue to its general position, must be accepted with some reservation, since these spaces will vary in obedience to changes in the inclination of the strata, and in the slope of the surface.

One of the localities at which we may examine the position, magnitude, and thickness of the ore, is on the S. side of the ridge 2½ miles E. of Danville, upon the farm once before alluded to as the property of the Bloomsburg Company. Here the outcrop of the ore is distinctly traceable in the slate, and its place is about 750 feet N. of the Iron-sandstone. A careful inspection of the fragments on the surface indicates its thickness to be about 7 or 8 inches, while their external appearance implies their good quality, or richness in the iron.

Another point at which the ore is well revealed is about 4 miles E. of Danville, on the N. slope of the mountain. At this spot the bed attains unusual thickness, and is mined in a somewhat systematic manner by the proprietor or lessee of the land, Mr Samuel Wood. The ore, which appears to exist in more than one stratum, resembles closely the Iron-sandstone ore of Danville; though of somewhat variable dimensions, the principal layer is from 18 to 30 inches in thickness, but every portion of this is not of the maximum degree of richness in the oxide of iron. This portion of the Northern outcrop, although at present but imperfectly developed, gives indications of its containing a very valuable amount of this important ore-bed. It is upon this belt, about 1½ miles further Eastward, that the ore is mined on the Bittenbender tract by the Bloomsburg Company. There the principal seam would appear to possess a less thickness than at the locality last mentioned, the bed, as displayed in one small drift, measuring only 8 inches. Fragments of the ore, indicative of a rather greater thickness, are, however, occasionally to be seen on the surface, and especially in the ravines below the line of the outcrop. Should this ore, which is amply rich enough for the furnace, and well adapted, in its chemical composition, to blend with an equal mixture of the soft and hard varieties of the fossiliferous ore in a triple mixture, prove on more extensive research to be sufficiently expanded to admit of being profitably mined, it will become a very valuable addition to the mineral wealth of Montour Ridge. The question of the actual amount of available ore along this line of outcrop is at present not susceptible of determination, and I shall abstain from an estimate which would necessarily be very conjectural.

The reader must bear in mind, that although much uncertainty prevails concerning the real quantity of this hard ore of the lower slates, little or no doubt can exist as to the permanency of the valuable fossiliferous ore along both slopes of the ridge. I have already intimated that every longitudinal mile on each outcrop may be estimated to yield of the soft variety of the ore about 50,000 tons, or, making due allowance for ravines, more correctly, between 40,000 and 45,000 tons. Moreover, it should not be overlooked that a portion of the compact or calcareous variety may in certain localities be advantageously mined where transverse ravines and notches give ready access to the bed. Montour Ridge consists, as I have shown, of two separate anticlinal ridges, the axes of which are not precisely in one continuous line. At the passing or overlapping of these two waves in the strata, there is of course an irregular synclinal trough, and although both the lower ore-beds,—that of the Surgent lower slate, and that of the Iron-sandstone—are here depressed below the water-level at Hemlock Creek by the subsidence of the two anticlinals, the fossiliferous ore is not, but, on the contrary, is more extensively spread over the surface of the hill than at any point further W. The Section (fig. 82) of the end of the main or Western ridge shows its structure immediately W. of Hemlock Creek; the observer looking W.

The ridge is shown to retain nearly its full breadth, and to contain, besides its own proper anticlinal (seen on the left) the nearly exhausted wave of the E. Fishing Creek Ridge. This section renders apparent the reason of the much-increased amount of the fossiliferous ore here found above the water-level, for it exhibits the comparative flatness of both anticlinals, in virtue of which the strata, in attaining a given height above the valley, spread themselves in a longer and gentler slope than where the anticlinal is higher and its flanks steeper. But besides this increased extent in the ore-bed on both sides of the ridge, there is another and very valuable portion occupying the N.E. flank of the end of the mountain, in the form of an oblique basin or synclinal, where the ore, being sheltered in the trough, has escaped the destructive agency of the waters. It is obvious, from the comparatively flat position of a large portion of the ore-bed, and from its conforming extensively in its slopes with the inclination of the surface, that it is here spread out under a relatively shallow covering, and in a situation especially favourable to the conversion of a more than usual amount of it into the highly-valuable soft variety. To these structural conditions we must impute the wide distribution of the outcrop ore on both the E. and W. sides of Hemlock Creek, and its singularly accessible situation for mining.

Montour Ridge E. of Hemlock Creek.—I now proceed to a brief description of the structure and resources of the Eastern or Fishing Creek division of Montour Ridge. This is a very regular and beautiful anticlinal, commencing, as we have seen, a little W. of Hemlock Creek, on the N. flank of the main or Mahoning division of the ridge, and terminating about 3 miles E. of Bloomsburg. It is thus about 5 miles in length; its extreme breadth is perhaps three-fourths of a mile, while its height is between 400 and 500 feet. The only irregularity in its generally symmetrical oval form is along its N. side, where a large segment has been scooped out of its base, to form a part of the valley of Fishing Creek. In their carving action, the floods removed from this flank of the anticlinal a very considerable portion of the bed of fossiliferous iron-ore, which elsewhere mantles the whole N. slope of the ridge.

As represented in the forgoing section of the strata in the meridian of Fishing Creek, the flexure in which they span the ridge is almost perfectly symmetrical; perhaps the N. dips are somewhat the steepest. The whole amount of the vertical upheaval of the rocks upon the anticlinal axis, compared with their elevation in the main W. ridge, is less by several hundred feet; for while, in that part of the mountain, even the Levant white sandstone is in one place lifted to the water-level, and the summit for many miles exposes the lower and middle members of the Surgent lower slate, the lowest strata upraised to the day, in this other division of the chain, are those of the upper half of the Surgent lower slate.

In the Western hill the Iron-sandstone rests for a great space low on its two flanks, but in this E. anticlinal it almost overarches the summit even at its highest part; in the Western ridge, again, the ore of the lower slate mounts high on the slopes in two widely-separated outcrops, whereas here it is not elevated to within probably 100 feet of the water-level. Connected, therefore, with this seemingly trivial circumstance of a difference of vertical uplift of about 450 feet, are several very important peculiarities in the condition of the ore.

In the first place, the ore-bed of the Surgent lower slate is altogether absent at the surface, and can only be made accessible by means of a vertical shaft sunk over the crown of the anticlinal arch in the middle of the gorge of Fishing Creek. Such a shaft, starting near the water-level, would descend between 100 and 150 feet through the slate before it would reach the layer of ore. To construct such a mine-shaft would not involve a cost at all commensurate with the importance of a productive bed of iron ore, of the quality which the band in question usually possesses, but in the existing uncertainty respecting the dimensions of the bed, there is but little to induce such an enterprise. I would, nevertheless, advise its construction at no distant day, should the ore at the Bittenbender tract prove of insufficient thickness to warrant its being mined. We have already seen that this ore is very variable in its dimensions, and there is about an equal chance for and against its being here met with of such diameter as to make it a very important auxiliary to the native iron wealth of the Bloomsburg neighbourhood.

The next bed of ore in the ascending series is that of the Iron-sandstone formation. This band of rocks spans the mountain at Fishing Creek to a great elevation, and both there and in other parts of the ridge is sufficiently well exposed to admit of its being critically studied. It is to be seen artificially and naturally developed, and very nearly of the type which it presents at Danville, at the N. base of the hill on the bank of the canal, which supplies an ample water-power to the furnace in the ravine of Fishing Creek. It agrees in all essential features, except in that which is of chief practical interest, the bed of silicious iron-ore. The very stratum, answering to the ore-bed, can be recognised as holding the exact position occupied by the layer at Danville, but it does not contain more than half its proper proportion of the oxide of iron requisite to constitute an iron ore. In other parts of the outcrop of the sandstone, a precisely similar deficiency is discernible in the layers holding the horizon of the ore, and we may therefore regard it as a definitely-settled fact, that throughout all this portion of the belt the Iron-sandstone ore, as such, has no existence.

It would thus appear that the only available ferruginous stratum is the fossiliferous iron-ore of the Surgent ore shales. Restricted as this part of the chain would at first sight seem to be as to its share of ore, it is nevertheless one of the most richly endowed of all the localities; and here we have a beautiful example, among innumerable others, of the simplicity of nature's means for effecting the most striking compensations.

Though the fossiliferous ore alone occurs above the water-level, it is made, by the admirably-balanced influence of a particular degree of elevation of gentle curvature, and of denudation in the anticlinal wave, to hold just that position which is nearly the most favourable we can imagine for causing it to mantle the sides and ends of the ridge in an extensive sheet for producing the maximum amount of the soft or infiltrated ore, and for rendering its outcropping portion widely and cheaply accessible under a thin covering of loose superficial slate. In consequence of the oval form of the hill, connected with the gradual rising and expansion of the whole anticlinal, from Hemlock Creek to Fishing Creek, and its declension and contraction thence to its termination, the ore laps broadly, as I have already intimated, over both of its extremities, but does not rise high upon its N. and S. slopes. This produces, of course, a less amount of breast on the sides than at the ends. But there is a further difference in the value of the ore-ground in these two positions, growing out of the very different extent to which the ore in its respective places has been deprived of its excess of calcareous matter, by exposure to surface percolation. Along both flanks of the ridge, the inclination of the strata exceeding very considerably the slopes of the surface, there is a rapid increase in the thickness and compactness of the slate formation reposing upon the ore-bed, and consequently the depth to which the superficial infiltrations have had access is comparatively limited.

Thus it is, that in these positions we usually find the change from the soft or dissolved part of the bed to the compact, to occur at a point from 30 to 40 yards below the actual outcrop.

On the other hand, at the two extremities of the ridge, the ore-bed mantles over and around the long and gently-declining terminations, in a dip which is much more nearly coincident with that of the surface above it, and therefore a far wider outcrop of it is thinly overlaid by the slate, and penetrated and altered by the atmospheric waters. This circumstance, and the much longer breast of ore spread out where the inclination is thus gentle, confers a greatly superior value upon these terminal portions of the ridge. In proof of this assertion it may be stated, that while on the sides of the mountain the soft ore occupies but a narrow line, it covers almost the entire E. point of the ridge. Actual excavations for the furnaces, and numerous exploratory shafts, render it almost certain that the soft ore spreads across the end of the ridge in a continuous sheet underlying perhaps some 150 acres, or more, at a depth below the soil in few places exceeding 20 feet.

The Bloomsburg Iron Company, owning two large furnaces in the gorge of Fishing Creek, and using largely this soft variety of the fossiliferous ore, possess upon this extensive ore estate rather more than 2½ miles of the outcrop of the bed along the sides of the ridge, and in addition about 45 acres continuously underlaid by the soft ore in the E. end of the hill between 2 and 3 miles of Bloomsburg. Each acre of the ore stratum contains, according to the most moderate calculation, not less than 3000 tons of ore, and the whole estate of the Company has upon it between 200,000 and 250,000 tons of the soft outcrop ore, while I have estimated the quantity of the hard or calcareous fossiliferous ore, in a readily accessible position, at not less than 70,000 or 80,000 tons. When we advert to the admirable quality of the iron derived from a mixture of ores possessing a large proportion of the soft fossiliferous variety, and to the superior ease and economy with which it may be smelted, we cannot but esteem this whole E. anticlinal district of Montour Ridge as one of the most fortunately-conditioned ore localities in the United States.*

Of the total Quantity of Iron Ore in Montour Ridge.—To render this description of the native riches of Montour Ridge more satisfactory, I shall endeavour, in conclusion, to deduce from the foregoing data some general estimates of the aggregate mass of the iron ore in this favoured tract. But it will be requisite, as a preliminary point, to determine the quantity that reposes upon the slopes of the E. or Fishing Creek division of the chain. Of course we can only form at present a rough approximation to the actual area occupied by the available part of the ore stratum; but even an imperfect calculation cannot fail to be useful to those interested in the resources of the region, and instructive to the general reader.

Of the more valuable variety, the soft or porous fossiliferous ore, we are warranted, I think, in assuming the quantity which overspreads the E. point of the ridge at 150 acres, and that resting upon the W. end, near Hemlock Creek, at about 50 acres.

To this amount we must add that belonging to the two long lateral outcrops. If strictly unbroken, each of these latter belts might be stated at perhaps 4 miles in length, making 8 miles for the whole; but we must deduct the vacant space on each flank of the ridge at the gorge of Fishing Creek; also that upon the N. slope E. of the Notch, where much ore has been swept away; and thirdly, the many smaller breaks produced by the hollows or ravines. Allowing one mile of soft ore as lost by all these interruptions, there will still remain 7 miles of outcrop. Let us adopt the above data, and we have from the first source 200 acres, yielding 3000 tons per acre, or 600,000

* The above estimates were made in 1846, from all the data then accessible.

tons ; and from the second, a belt 7 miles, or 12,320 yards in length, and 30 yards in breadth, giving 30 tons to each yard along the outcrop, or very nearly 370,000 tons in addition. The total amount of soft ore is therefore about 970,000, or approximately 1,000,000 tons.

It is much more difficult to speculate with any accuracy upon the aggregate quantity of the compact calcareous ore available for practical purposes ; for we know as yet too little concerning the rate at which this deteriorates in descending, the limit of depth of such deterioration, and the steadily increasing cost of reaching it, whether by tunnels or by machinery, to affix accurate limits to the economical working of the stratum. This ore is, moreover, intrinsically so much less valuable than either the soft fossiliferous variety or the silicious block-ores, that the limits here mentioned will be the sooner reached. With the restricted value which it must always possess so long as the soft variety lasts, I cannot conceive that it will be mined to an average depth of more than 30 or 40 yards, and it is very questionable if it will admit of being generally wrought to even that extent. If we suppose, as we may, that it possesses a total length in its circuit round the ridge of about 9 miles, we may infer the entire available quantity to be about 500,000 tons ; and such will be nearly the amount wanted for mixture with the other ores—these having the quantities I have respectively assigned to them.

Let us, in the next place, examine the capacity as to ore of the W. or Mahoning Creek division of Montour's Ridge, the productive outcrops of which commence at Hemlock Creek, and seem to terminate within one mile W. of Danville, except perhaps that of the N. flank, which may extend somewhat farther.

Adverting first to the fossiliferous ore, we shall probably be correct, if, after rejecting the many interruptions which it encounters from ravines, including the wide gap of the Mahoning, we ascribe to this bed a length of outcrop equivalent to 8 miles on each side of the mountain, or a total length of 16 miles. If we now assume 30 yards as the average height of the belt of soft ore—and I am disposed to think this somewhat too large an estimate for the portion of the ridge under consideration—the total quantity of this outcrop variety will be at most but 210,000 tons. Admitting that the compact calcareous kind can be wrought to an additional depth of 30 yards, the available supply of this variety will be the same, or another 210,000 tons.

Respecting the hard block-ore of the iron sandstone, it has been already shown that this bed loses its valuable thickness and richness within 1 mile or 1½ miles E. of the Mahoning Gap, while we know that it is not traceable on the S. side of the ridge beyond the commencement of the Narrows. If we assume the productive portion to constitute in all a length of outcrop equivalent to 4 miles, or about 7000 yards, we shall probably not underrate its actual extent, while we may safely estimate the average length of the slope above the general water-level as not exceeding 200 yards. It has been already shown, that, on the supposition of an average thickness of 14 or 16 inches, or about one ton of the ore to the square yard, the whole quantity in one such mile of outcrop is a little more than 350,000 tons. The total supply, therefore, from above the water-level, if our data are correct, will somewhat exceed four times this amount, or 1,400,000 tons.

Our next and last estimate concerns the hard silicious ore of the Surgent lower slate, but in the present imperfectly-developed state of this bed, the data are insufficient for speculating upon the probable aggregate amount of its ore possessing the essential degrees of richness, thickness, and accessibleness. It is nevertheless obvious enough that the total length of the available belt is but a small fraction of its entire outcrop. I imagine it not to exceed 4 miles, and to fall probably much within this conjectural length. The position of much of this ore is such, in relation to the steeper slopes of the ridge, as to preclude its being very extensively wrought, since the tunnels, in the side of the mountain, requisite to command a large quantity above the water-level, would be of great length, and of a cost disproportioned to the value of the ore. Only the parts near the outcrop, and accessible from the ravines, can be profitably mined at the present prices of labour. If we estimate for this ore a depth of breast equivalent on an average to 50 yards, and even assume its thickness such that one square yard will represent one ton, we shall have for our conjectural belt of 4 miles a total of 352,000 tons of ore.

Let us now assemble together the above several numerical results, and ascertain the entire quantity of ore in an attainable position in Montour's Ridge, and available by the present generation:—

Of the soft fossiliferous ore—	
The Fishing Creek anticlinal contains	1,000,000 tons.
And the Mahoning Creek anticlinal	210,000 „
The total quantity of soft ore is therefore	1,210,000 „
Of the calcareous fossiliferous ore—	
The Fishing Creek anticlinal contains	500,000 „
And the Mahoning Creek anticlinal	210,000 „
The total of calcareous ore is therefore	710,000 „
Of the silicious ore of the iron sandstone—	
The Mahoning Creek anticlinal contains	1,400,000 „
Of the silicious ore of the Surgent older slate—	
The Mahoning Creek anticlinal contains	352,000 „
The total of silicious ore is therefore	1,752,000 „
The grand total of ore in Montour's Ridge is therefore . .	3,672,000 „

In reviewing these results, we are impressed with the interesting and very important fact, altogether unanticipated until this calculation had been completed, that the entire mass of the soft fossiliferous variety is about one-third of the whole aggregate of ore in the belt; and experience has already fully demonstrated, that in smelting these several ores together, the lowest proportion in which this admirable variety can be employed to insure excellence in the iron, and economy in the working of the furnace, is about this ratio of one-third. Should the other kinds be ultimately ascertained to exist in quantities materially greater than those I have assigned them from calculation, the portion in excess above my estimate will, after the exhaustion of the soft fossiliferous sort, possess but comparatively little value, through the lack of a fitting ore wherewith to mix it.

An interesting inquiry here suggests itself, as to the probable duration of this apparently inexhaustible amount of ore, under the active consumption which is now going on. According to the most accurate information I have been able to procure, there have been, for the past several years, about twenty furnaces, some of the largest dimensions, some of medium capacity, deriving their supplies of ore from this single belt. To each of these furnaces we may attribute, without exaggeration, an average annual productiveness of 3000 tons. If we now reason upon the basis that these ironworks must hereafter, if they have not already, put themselves on mixtures of the several ores, in which the average proportion of the soft fossiliferous sort shall not surpass one-third, we must assume that it will demand three tons of the mixed ores to yield one ton of metal. The average consumption for a furnace must therefore be about 9000 tons per annum, and the total yearly supply for the twenty furnaces not less than 180,000 tons. But at this rate of consumption, the seemingly vast aggregate of available ore in Montour's Ridge is destined to be entirely exhausted in the short space of twenty years. It should be kept in view, that this somewhat startling inference assumes a still graver aspect, when we reflect on the probable steady future augmentation, for a time at least, in the number of the furnaces which will seek for their supplies of ore from this important belt. Stimulated as the prosperous iron manufacture of Pennsylvania is at present by the seemingly well-grounded anticipations of sustained prices and a future vigorous growth, the calm counsels of prudence and dispassionate science have little chance of being heard and adopted, until loss and suffering to a greater or less extent, through a too lavish application of capital, shall recall their suggestions.

In the hope, however, that opinions drawn from an honest and laborious investigation of the facts, and expressed through no motive but one of duty, cannot pass altogether unheeded, I here venture, in closing this subject, earnestly to press upon the ironmasters consuming, or about to consume, the iron ores of Montour's Ridge, to economise their soft fossiliferous ore, the quantity of which is far from boundless, while the possession of it in a certain proportion is vital to their prosperity. Let them, in every instance where it is practicable, reduce the proportion of the ore in their mixtures to one-half or even one-third, and let them not forget that this ore is the present key to all the remaining riches of their region, that when it fails them much of the other ore must be left untouched where it now reposes, and with its final exhaustion must come an enormous, almost a total, loss of all their fixed investments.*

* The above estimates and views were committed to paper in 1847, and though some fresh developments have extended a little the area of the soft ore, time has fully confirmed their general soundness.

CHAPTER III.

SCALENT, PRE-MERIDIAN, MERIDIAN, CADENT, AND VERGENT ROCKS OF THE ANTICLINAL BELT OF MONTOUR'S RIDGE.

THESE strata, as they are seen in their outcrop encircling Montour's Ridge, have been already described in a general way, and it is only necessary to introduce here a few local details. The most Eastern clear exhibition of the series is about 6 miles W. of Berwick, in a ridge half a mile N. of Harman's. The N. and S. outcrops uniting in this vicinity, the lowest of these formations, the Scalent limestone, disappears in a point upon the anticlinal axis perhaps 2 miles further E., being buried by the overlapping of the higher rocks. Opposite Harman's, the limestone is quarried to a considerable extent, this being the most E. locality, in the valley of the North Branch of the Susquehanna, at which that valuable material appears near the surface. The rock here is chiefly the Scalent limestone, the overlying Pre-meridian limestone being extremely thin, and the Meridian sandstone absent.

At these quarries we may behold the chief part of the Scalent limestone, the portion visible being perhaps 50 feet in thickness. Its lowest layers are argillaceous, and are separated into very thin bands, seldom more than one inch in depth. Ascending, these become thicker, and contain more fossils. In the lower beds, the only species is the *Cytharina alta*, but in the upper portions this fossil is associated with a few shells, &c. At this locality the strata dip 30° to the S.S.E.

Traced W., the limestones separate into two narrow belts, one ranging parallel with the N. the other with the S. base of Montour's Ridge, and not coalescing again until they reach Buffalo Valley in Union County. The usual position of each outcrop is in the valley encircling the main anticlinal ridge. Neither line is continuously exposed, the S. one especially being obscured for considerable spaces by diluvium, and in certain localities—as near Bloomsburg and at Danville—by being cut down to near the water-level, and covered with the river alluvium. On the S. side of the ridge, the limestones are well exposed in the channel and banks of Fishing Creek, and on the river-side at the Danville Bridge, and in intermediate places the N. outcrop is more resorted to for limestone, from its being thicker and better exposed, and it is quarried in several places near the gaps of Fishing, Hemlock, and Mahoning creeks. The upper or Pre-meridian limestone increases in thickness as we trace it S.W. The following table displays the composition and contents of the whole Meridian and Pre-meridian series, with the underlying Scalent limestone, as they are exhibited at the quarries 2 miles S.W. of Bloomsburg, on the road leading to Danville.

Meridian,	Slaty Sandstone, . . .	30—40	No fossils discovered.
	Slate, ...	20—30	
Pre-meridian Limestone,	Chert—thin		Favosites, Catenapora (several species); Ceriopora; other small fossils; Cyathophyllum (?); Encrini; Atrypa (small, with attenuated whorls); Trilobite buckler; Atrypa, like *O. Testudinaria.*
	Limestone—massive and blue—	60	
Scalent Limestone,	. . . .		Cytherina (not found in the limestone above, at the Quarry).

From this table it will be seen that the Scalent limestone is characterised as usual by its fossil, the *Cytherina alta*, while the Pre-meridian limestone abounds in shells and corals. This latter formation is 60 feet thick in this place, and is capped by a thin bed of chert. The Meridian sandstone is absent, but the middle formation, the Pre-meridian slate, consisting of its dusky slate and slaty sandstone, have a thickness of about 60 feet. In immediate contact with the latter is the Cadent black slate.

In the vicinity of Mooretown, on the road leading thence to Lewisburg, the N. Meridian belt is visible in a low range of hills about one mile N. of the foot of Montour's Ridge. Its position is marked by much loose chert and fragments of the Meridian slaty sandstone, the beds of the latter stratum appearing at intervals along the ridge in place, with a N. dip. The black and dusky ash-coloured Meridian slates are seen resting directly on the limestone in several places, and over them the slaty sandstone, but little or none of the coarse Meridian sandstone, with the large hollow casts left by its fossil shells, is discernible. The slaty sandstone contains several distinctive fossils, one species being a large *Orbicula,* also a small *Delthyris.*

Cadent and Vergent Rocks of the Anticlinal Belt of the North Branch of Susquehanna.—The Cadent and Vergent rocks of this anticlinal zone, commencing at the N.E. near the sources of the Wapwallopen, extend in a gradually-expanding tract down the valley of that stream to its mouth, and thence along the Susquehanna to the point between Berwick and Harman's, at which the Pre-meridian, Meridian, and Scalent strata rise to the surface, and divide the strata into a North-dipping and a South-dipping tract. These two divisions range thence in two chains of hills parallel with the two sides of Montour's Ridge, and unite W. of the West Branch of the Susquehanna. A glance at the Geological Map will make the N. and S. margins of these two tracts sufficiently apparent. The N. boundary of the Cadent and Vergent strata, from the vicinity of the Mahoning Creek east, is formed by the Ponent rocks of the Wyoming synclinal, but from that point W. the belt is but the S. side of the synclinal trough, the Cadent and Vergent rocks forming the Mahanoy Ridge.

The Synclinal Belt of Mahanoy Ridge and Buffalo Valley.—An inspection of the Map and of the general sections will sufficiently familiarise the reader with the outlines of the synclinal belt lying next N. of the anticlinal tract of Montour's Ridge. This belt is the prolongation of the trough of the Wyoming coal valley, and contains, within the region we are describing, the W. end of that basin, surrounded by the Vespertine rocks terminating in the synclinal knob of the Shickshinny Mountain. To the S. and N. of the two mountain-ridges of Vespertine conglomerate are two belts or outcrops of the Ponent rocks, the S. one lying N. of the Wapwallopen and the North Branch, and the N. one S. of the Post-meridian anticlinal belt of New Columbus and Three-corner Pond. These two zones of Ponent red sandstone unite round the W. end of the Knob Mountain near Fishing Creek, and are thence continued in a single tapering belt, which terminates in a point near Mahoning Creek, S.W. of Jerseytown. Beyond the end of the Ponent strata, the synclinal tract contains only Pre-meridian, Meridian, Cadent, and Vergent strata, as far as the Susquehanna. The Mahanoy Ridge consists of the Vergent rocks of the middle and N. side of the trough, the Pre-meridian and Meridian rocks appearing in a narrow outcrop on the S. side of the whole belt, and likewise on the N., as we approach the West Branch of Susquehanna.

Prolonged across the river into Union County, the synclinal axis of this belt passes through Dale's Hill in Buffalo Valley, but the whole of the S. side of Buffalo Valley is to be regarded as the Western extension of the trough.

DIVISION II.

SECOND BELT OF THE FIFTH DISTRICT OR ANTICLINAL NORTH OF SHICKSHINNY MOUNTAIN.

CHAPTER I.

THE ANTICLINAL BELT OF UPPER FISHING CREEK.

A BROAD anticlinal region of Vergent rocks, supporting on either side the Ponent series, separates the Vespertine rocks of Elk or Tunkhannock Mountain on the N., from the Vespertine of the Shickshinny Mountain on the S., crosses the Susquehanna North Branch between Tunkhannock and Pittston, and issues, between the North and Knob mountains, upon the open country of the West Branch around Fruitstown. Throughout its more Eastern portion it is a single, very broad, and gentle anticlinal flexure, as far as the North Branch of the Susquehanna; but, upon reaching the West Branch, it subdivides into a series of sharp and narrow flexures. Each more Southern of these flexures originates a little further W. than the origin of the one next N. of it, and all together run W. in six or seven parallel lines, entering as many separate knobs of the range of the Buffalo or Seven Mountains.

From Montour's Ridge to the Alleghany Mountain, as far W. as Fruitstown, all the rocks are either Cadent or Vergent, spread out by the rising of these anticlinals. The Pre-meridian limestone makes its first appearance 4 miles W. of Fruitstown, emerging from under the Meridian sandstone upon the axis of one of the Northernmost anticlinals. It is afterwards brought to day by all the flexures in a series of zigzag curves running off S.W., and curving round the W. end of the synclinal trough of the Mahanoy Ridge. Its N. outcrop runs W. across the river into Whitedeer Hole Valley, encircles the end of the similar synclinal trough of the Muncy Hills, and recrosses the river at Muncy. To the W. of, and within this broad zigzag belt of Pre-meridian and Scalent limestones, the seven anticlinals bring up long narrow points of Surgent marls, shales, and slates, which spread out as a zigzag belt along the base and on the flank of the range of the Buffalo Mountains, the Levant white sandstone knobs of which are the crests of the anticlinal waves. These spurs or knobs divide or fork Westward, and admit the Matinal slate and Auroral limestone between their branches in the long anticlinal valleys Kishacoquillas, Sugar Valley, Nittany Valley, &c.

The region between the Wyoming coal basin and the Alleghany Mountain, traversed by the broad general anticlinal, is a high and rough country, watered by numerous streams, dotted with picturesque lakes,* and still covered to a great extent with the original forest, but sufficiently

* Of these, Hervey's Lake is the most celebrated, and deserves the notice of travellers. The loneliness and wildness of its truly beautiful shores excite the admiration of all who penetrate the forest to its quiet waters.

arable in its slate hills and alluvial strips of bottom land to invite industrious and increasing colonies of new settlers. But E. of the North Branch of Susquehanna, where the opposite dips of the great flexure are almost horizontal, and the lateral belts of Ponent sandstone encroach upon the middle portions of the valley, and cover almost every summit between the streams, the whole region is scarcely more practicable for farming than the roughest portion of the mountain-ridges. Nor are these disadvantages compensated for by mineral resources, for these are not of great value. The ore-bearing stratum near the upper limit of the Vergent series will be found, no doubt, to range along both sides of the great anticlinal valley, but experience of its quality elsewhere, as at Larry's Creek, excites no very sanguine expectations regarding it.

The level land between the limestone ridge on the S., and the outcrop range of the Vergent flag formation forming Muncy Hills to the N. and E., is a rich agricultural district, with sluggish streams, and spaces that are marshy in wet seasons, but exceedingly fertile. Such is the well-known Black Marsh. In passing N. across this belt, one leaves the South-dipping Vergent rocks of the Mahanoy synclinal ridge, and crosses Cadent olive slates. The Cadent older black slate appears dipping 28° S. to 35° E. upon the banks of the Chillisquaque. If the line be drawn direct to Fruitstown, these rocks, almost horizontal, with alternately N. and S. gentle dips, are the only ones observed. If a section be chosen through Washingtonville to the Muncy Hills, limestone occurs, dipping alternately N. and S. Not a fragment of Meridian sandstone, however, is to be seen. This formation seems to be wholly absent here.

The first exposure of the limestone occurs, perhaps, one mile to the N. of the Mahanoy Ridge.

At Sidell's Tavern, between Jerseytown and Washingtonville, two quarries show pure deep blue limestone in layers from 3 to 18 inches thick, dipping 25° N.E. It contains some sulphuret of iron. A rock similar in dip and character is seen at Delavie's Quarry, 1½ miles N.W. of Washington, but here, between the layers, are soft ash-coloured beds, full of fragmentary fossil-shells. Above it, at some little distance, are buff shales.

On the borders of the village of Paradise, at the S. edge of the Black Swamp, 5 miles N. of Washingtonville, the deep-blue limestone contains a few fossils. A little W. of this, at Snyderstown, the rock spreads out in horizontal layers over a large district.

CHAPTER II.

THE SYNCLINAL BELT OF MUNCY HILLS, ETC.

The Buffalo Mountain flexures, dying out E. into one broad anticlinal, divide the region of the Cadent and Vergent rocks at Fruitstown : the S. sweeps S. to form the Mahanoy, or more properly the Chillisquaque Ridge ; the N. forms the wide belt of Muncy Hills, which, broken through transversely by the West Branch below Muncy, and tapering to a point W. in the heart of the Whitedeer Hole Valley, spreads itself E. around the synclinal Ponent and Vespertine

* From Jerseytown to Fruitstown olive slates frequently appear, also washes of black slate and black slate *in situ*, nearly horizontal, 2 miles from Fruitstown. At Jerseytown it dips 28° S. 60° E.

shoulder or knob of the Alleghany Mountain, called the North Mountain. In all respects this ridge corresponds to that of the synclinal belt of the Mahanoy Ridge already described.

The Cadent olive slates at the base of the Muncy Hills do not seem here to be very fossiliferous, nor could the fossiliferous calcareous strata be discovered, but admirable exposures of Scalent limestone and Meridian slates are afforded by the river. In describing the country upon the W. side of the river, we will begin with Whitedeer Hole Valley.

Whitedeer Hole Valley.—The bounding mountains are the Bald Eagle on the N., and the Whitedeer upon the S. The surface is much broken and traversed by a few small streams which run along the outcrops of the formations, and yield few transverse exposures useful to the geologist. But the river, sweeping round the end of the Southern mountain, reveals the structure. Here the Levant white sandstone rises in the axis of the flexure, and over it, dipping N., descend successively the Surgent slates, and calcareous shales, and Pre-meridian limestones; and lastly, Cadent olive slates and Vergent sandstones in the trough.

The Surgent Red Shale is well exposed at the mouth of Whitedeer Creek; the Scalent limestone, and variegated blue and brown calcareous slates, appear up the creek, along the foot of the mountains.

The Pre-meridian Limestone first appears three-fourths of a mile N. of Uniontown. It is massive, pure, full of encrini and shells below, more and more silicious above, until it passes upwards into the Meridian calcareous sandstone, full of large fossil-casts. This is admirably exposed on the E. side of the river. Its dip is 20° N., from 5° to 10° W.

Cadent Black Slate reposes upon the sandstone, and is exposed for half a mile. It seems nearly destitute of fossils, and has been, as in so many other parts of the State, foolishly mined in search of coal. One of the galleries was made to follow a bed of nodular sulphuret of iron, the nodules from 1 to 5 inches in diameter, and packed like eggs, compact, heavy, and breaking with a dark-grey lustre. The slates are here fossiliferous, but not calcareous. N. of this they graduate into the Cadent olive shale, which is compact and massive, succeeded by a darker variety. About one-fourth of a mile further N., and the same distance S. of Bellman's Tavern, two quarries are opened in blue calcareous slate or argillaceous limestone, compact, massive, spotted on the weathered surface, and interstratified with thin soft seams, full of shells, encrini, &c. Above the upper beds are more dark shales dipping 20° N.

The finest exposure of the Cadent olive slate is at Bellman's Tavern, in the bluff end of Penny Hill, dipping N. The South-dipping portion of the synclinal ridge is swept away.

Hence, N. across Black Hole Valley to the Bald Eagle Mountain, the same rocks come up again, but their outcrops are covered by diluvium. Little search has been made for the outcrop of the limestone; it may be readily traced, however, by a line of sink-holes running E. and W.

Surgent Rocks of Whitedeer Hole Valley.—The calcareous and silicious Surgent rocks form a line of hills from the river W. along the foot of the Bald Eagle and Whitedeer mountains. The red shale appears in the transverse ravines as at Hunter's Mill, and 1½ miles above the mouth of Whitedeer Hole Creek. The fossiliferous iron-ore was not here discoverable at the time of our survey, although fragments of the iron sandstone were seen. The creek here flows N. of the red shale, but at Graff's Tavern, 2 miles W., it washes the red-shale hill at its foot, and reveals the calcareous ore-shales along its banks.

Rough irregular massive Scalent limestone, much pressed and fractured, and full of white veins of spar, is seen one mile S. of Moon's house.

Pre-meridian limestone is opened at Marsh's Quarry, 2 miles W. of Graff's Tavern, and between it and the mountain the Surgent calcareous ore-shales occur on the farm of William Moore. The most Western exposure of red shale is about 12 miles from the river, 2½ miles W. of McCurdy's Mill.

Along the N. side of the river Surgent exposures are very rare. The ore shale is seen dipping 30° S. 35° E. at Mr Woodley's house. The whole mountain-slope, stretching far into the valley, is usually covered with blocks of Levant white sandstone, and overgrown with scrub oak and dwarf pine as far as the head of Black Hole Creek.

Pre-meridian and Scalent Limestones of Whitedeer Hole Valley.—The Pre-meridian may be traced round its whole outcrop, from the river back to the river again. Its S. outcrop shows its transition into the silicious meridian sandstone, with large fossil-casts, very admirably. Midway in the mass the fossils change to those of the Scalent type, and the limestone itself becomes quite pure. The W. part of the outcrop forms a broken low limestone ridge, upon which are many quarries.

On the N. outcrop it may be studied at White's, 12 miles from the end of Bald Eagle Mountain, where the blue limestone, with few fossils, dips 38° S. The fields are covered with fragments of Pre-meridian chert, full of fossils. The limestone appears at Mr Lee's, near which a brook sinks into a cavern in the outcrop, to reappear again at the Big Meadows. At George's, 10 miles from Muncy, the limestone is almost a solid bed of madrepores, giving it a concentric nodular structure. In a sink-hole at Walter's, 5 miles from Muncy, the rock is a hard grey impure limestone.

The *Meridian Sandstone* is nowhere seen in place in Whitedeer Hole Valley, but repeatedly occurs in the state of fragments full of hollow casts of fossils, along a line parallel with the sides of the valley.

Cadent Dark Olive Slate forms the central and highest part of the valley in Penny's Hill. The black and brown slates, with calcareous layers, outcrop round its base, and stretch much further W. than its W. point, which is but 2½ miles from the river. Black slate is exposed on Spring Creek, one mile N. of Graff's Tavern, many of the layers being calcareous, and all dipping N. This stratum has been often mistaken for a coal slate.

CHAPTER III.

BUFFALO VALLEY.

Buffalo Valley is 12 miles broad, if measured along the river from Whitedeer Mountain south to Longstown Ridge.

Nittany Mountain, rising from the plain along the S. side of Whitedeer Mountain, 4 miles W. of the river, narrows the valley by several miles. At the river both the N. and S. dips are about 15°.

Buffalo Mountain does the same, rising at 6 miles from the river by the side of Nittany Mountain. Its anticlinal crosses the river at New Columbia.

Mifflinsburg Mountain rises opposite the village of that name, formerly called Youngmanstown, 10 miles from the river. Its anticlinal axis crosses the river probably a few hundred yards S. of the Milton Bridge. This mountain ends at the opening of the Brush Valley Narrows, and contains the anticlinal of Pine Creek Narrows. Spruce Run flows round its end from the ravine valley behind. Parker's Sawmill is on the N. dip, and Kelly's on the S., both belts dipping about 25°. The axis line probably runs N. of Chamberlain's on Buffalo Creek, between 4 and 5 miles from Milton, and 6 from Lewisburg.

Hartleyton Mountain rises opposite the village of Hartleyton, 4 miles W. of the Mifflinsburg Mountain. Its anticlinal axis has not been traced to the river. This mountain ends opposite Orwig's, and contains the anticlinal axis of Penn's Valley, which is beautifully exposed, with gentle dips in the creek below Brook's Sawmill. It cannot be traced E. In the mountain are five several breaches—the gap of Buffalo Creek, Bartley's, Stony Run Gap, the gap opposite Raush's Tavern, and the gap through which the turnpike passes.

Paddy's "Path Valley" Mountain rises next, with an anticlinal axis which apparently crosses the river at Lewisburg. This anticlinal flexure is beautifully exposed where Laurel Run breaks through the mountain, with dips of 10°. It runs out N. of Hartleyton with a S. dip of 28°, and appears on Spruce Run, 2 miles W. of Hartleyton, near Breyfeyle's Sawmill on Buffalo Creek, at A. Orwig's Mill, 2 miles E. of Hartleyton, in older Surgent shale ; and half a mile N. of the turnpike is the red shale. It appears again on East Buffalo Creek, one mile above Rocky's Mill, on North Buffalo Creek, and near Souldy's Mill at the junction of Rapid Run and Buffalo Creek, where the S. dip is 60°, and the N. dip very low. About 2 miles N. of the turnpike at Mifflinsburg, the Surgent ore limestone dips S. 45°, and strikes the river below Lewisburg.

In a section from Young's Tavern to Rangler's Mill, the rocks are much disturbed. Near the tavern, one mile from the turnpike, the stratification is nearly vertical ; at Rangler's Mill, near the confluence of Spruce Run with Buffalo Creek, the impure limestone dips 15° S. ; and one mile further N., in Siebold's quarry, it is contorted limestone.

White Mountain succeeds, rising 5 or 6 miles W. of the last, with an anticlinal axis that is traceable along Penn's Creek, and runs just N. of Mifflinsburg.

The flexure is found on Penn's Creek below the "Deep-Hollow," not far from Mr Cook's. The Surgent ore shale limestone is seen dipping 60° N. close by. It is supposed to run through the hill N. of Mifflinsburg. The axis of the synclinal flexure between it and Jack's Mountain crosses Pine Creek below Miller's Sawmill, with a S. dip of 20°, and a N. dip vertical.

Jack's Mountain comes next, but instead of falling back in the oblique line with all the rest, it advances E. of White Mountain as far as the meridian of Mifflinsburg, forming, with the Longstown Ridge, its prolongation, the long straight S. boundary of the Buffalo Valley, while the White Mountain closes up the head of this.

Buffalo Valley is in a high state of cultivation, especially to the N.E. of Mifflinsburg. Long settled by an industrious people, well watered by large and rapid streams, and manured with lime burnt from the numerous quarries along its Scalent limestone outcrops, its yield of grain is perhaps as great per acre as that of any portion of the State. Pine Creek and Whitedeer Creek drain valleys which lie behind the mountains, and issue through wild gorges into this plain.

To the W. of Mifflinsburg the soil is inferior, because the rocks are different. The Premeridian and Scalent limestones are not found so far W., only the Scalent marls and Surgent shales and slate groups, with their scanty calcareous layers. These continue to occupy the narrowing basin, and are shut out at the head and along the sides of the valley by the rise of the Levant white sandstone of the mountains. But lime, if well employed as a manure, would make even this slate land a garden. The now almost useless limestone beds of the Surgent shales might be easily and efficiently used to remedy the deficiency of calcareous matter in the soil.

We proceed to describe the geological structure of the district in detail, by tracing the outcrops of the formations in the ascending order.

Levant White Sandstone.—This forms the crest and uppermost slope of the bounding mountains just described, from the end of Whitedeer Mountain round to the end of Jack's Mountain. At the termination of each mountain knob or axis of each anticlinal, the Surgent slates rise sometimes to the very summit. The marine plant *Arthrophycus Harlani* may be remarked in the white sandstone in great abundance.

Surgent Shales and Scalent Marls.—These occupy the chief portion of the valley, forming a broad band around its sides, and straight belts along the anticlinal flexures. The inner margin of the red shale is traceable from a point on the river a little below the Milton Bridge, W. and a little S. for 5 miles, thence S. to within one mile of the turnpike, thence W. of S., passing half a mile N. of Mifflinsburg, curving S. and S.E. $3\frac{1}{2}$ miles W. of Mifflinsburg, ranging thence E., parallel to the N. foot of Longstown Ridge, and distant half a mile from it. It sweeps off N. from the ridge, and retreats N.W. 2 miles, then curves sharply and runs E. a little N. for 4 miles, and so crosses the river one mile below Lewisburg.

These rocks may be studied at the end of Whitedeer Mountain, at the end of Longstown Ridge below Lewisburg, and in the New Berlin Gap through the same ridge, where, however, the Surgent calcareous shales or ore limestone beds are not seen.

Where Whitedeer Mountain sinks into several ridges at the river, the flaggy deep red argillaceous beds of the Levant white sandstone series, alternating with hard grey and white strata, are seen dipping 7° or 10° both ways upon the flexure. Going S. the dips increase to even 60°. The Levant sandstones are succeeded by silicious Surgent slates, which become more argillaceous, and of a buff colour, as we ascend in its thick mass. Over this lies an equally thick formation of ash-coloured, very fossiliferous slate; the whole dipping 25° S. This is olive-coloured, breaks into pencil fragments, and finally becomes calcareous as we ascend to the limestone beds of the Surgent ore shale group. Red shale appears next in the roadside, and over this again, at Caldwell's Mill, on the S. side of Whitedeer Creek, a quarry exposes argillaceous impure limestone of the Scalent series. Its dip is 45° S. This series corresponds to that already described upon the N. dips of this flexure, in Whitedeer Hole Valley, N. and S. of Uniontown.

The *Surgent Calcareous Shale, or Fossiliferous Ore Shale*, contains beds of limestone not well developed on the river at the end of Whitedeer Mountain, but it becomes valuable about 2 miles W. of Caldwell's Mill. Its beds jut out upon the river-bank S. of New Columbia, in masses like columnar basalt, but they are impure. A short distance W. they occur in a purer condition, and would make fair lime. They dip N. from the Buffalo Mountain anticlinal, and run thus 6 miles W. to the mountain.

About one mile below Lewisburg, a few hundred feet from the river, they are quarried near a stream, and 2 miles N. of Mifflinsburg there are two or three anticlinal hills, the tops of which consist of these limestone strata, coming up from under the red shales, for a width of half a mile. Between this point and the Brush Valley Narrows to the N., these limestones again make their appearance along the axes of the next anticlinal, and might equally well be quarried.

A third line of anticlinal outcrop occurs $2\frac{1}{2}$ miles W. of Mifflinsburg, and not far N. of the turnpike, at Orwig's Mill; it must pass not far to the N. of Hartleyton. Between Hartleyton and Jack's Mountain these strata do not show themselves, except at Peter Miller's Sawmill, on Penn's Creek, and about 2 miles further W. They occur in the deep hollow, 6 miles W. of Hartleyton, fully exposed, and of excellent quality, and should be wrought for the limekiln. Poorer strata are discoverable further W., as at a few hundred feet N. of Mr Cook's house.

In fact, the farmers might open these beds at very many convenient places along the foot of the mountains, underneath the red shale, *i.e.* between it and the mountain.

At Tait's, 2 miles N. of Hartleyton, the ore has been dug about half a mile above White's cabin, along the bank of a run. It is of a light chestnut brown colour, and yields not above 35 per cent of iron. It occurs in yellowish white clay. No rocks were observed in place to determine its geological position.*

At the foot of Jack's Mountain, half a mile S. 20° W. of Miller's Sawmill, extensive openings have been made in a ridge running parallel with the mountain.

The ore formed a bed between highly argillaceous clay walls, and was of two varieties; one like the foregoing, but richer, the other a hard and heavy blue ore.

About 10 miles W. of Hartleyton, between White and Jack's mountains, the iron ore has been obtained at a spot half a mile S. of the foot of Paddy's Mountain. It resembled the last-described, and was in connection with a white and very argillaceous sandstone, dipping S.

Minute examinations along the flanks of Longstown Ridge failed to discover the fossiliferous ore. The calcareous beds are difficult to find.

One mile S. of Lewisburg the red shale appears 400 yards to the S. of Turtle Creek, upon a little run; the calcareous layers dip 20° N., and 200 yards below the run, on the bank of the creek, are three ferruginous beds, each 4 inches thick, but so far apart that they cannot be wrought. They are full of fossils.

To the S. of the Buffalo Mountain, good iron ore in fragments lies scattered over Chamberlain's Hill.

About 4 miles W. of New Columbia, excellent ore was formerly opened in a nearly horizontal position, upon the axis of the Buffalo anticlinal. The bed is 12 inches thick. Not far N. of the last, a bed of good ore, also 12 inches thick, occurs in pure limestone, dipping 30° S.

Scalent Limestones.—This is merely the upper and more purely calcareous portion of the great Scalent marl group, which, beginning below in pure red shales, passes through alternations of olive calcareous shales of earthy aspect, often too argillaceous for use in the kiln, to pure massive limestone. The middle portion of the calcareous mass, or the Scalent limestone, yields the best lime. The upper portion, or the Pre-meridian limestone, is less available, from the

* Since the examination of this region by the State Survey, extensive systematic researches for the ore have been made by the proprietors, and the true fossiliferous ore-bed has been opened, and used in smelting-furnaces.

quantity of chert which it imbeds. Sometimes the chert is so abundant that the stone cannot be used at all. This is the case with beds at the quarries 1½ miles S. of Milton.

Numerous small quarries exist along the river near Milton. At Shaffer's and Hummel's quarries the limestone is argillaceous, and often pyritous, seams of sulphuret of iron occurring half an inch in thickness. This may bear some relation to the presence of *hæmatitic* iron-ore, strewed in abundant small fragments over the soil a short distance to the N. of Hummel's Quarry, and greatly checking vegetation. Little evidence is afforded of the presence of any valuable body of ore. In the woods to the N.E. are many fragments of a brown sandy ore.

Several quarries are opened in the sides and ends of *Dale's Hill*. This is a synclinal ridge, flat, one mile broad, and 2½ miles long, between the Paddy Mountain anticlinal on the S., and Hartleyton Mountain anticlinal on the N. Its E. end, 2 miles distant from Lewisburg, is prolonged in two diverging lines of low hills, enclosing a point of Cadent black slate crossing the river. Its medial or axis line shows horizontal dips increasing to 20° S. at its N. side, and to 30° N. at its S. side. Its surface is strewed with Meridian sandstone fragments, full of casts.

Quarries are opened along the sides of Longstown Ridge. This is of similar synclinal structure to Dale's Hill. Its steep sharp E. end approaches within 4 miles of the river, showing very gentle dips both N.W. and S.W. Its summit becomes broader as the basin deepens opposite to Mifflinsburg. Its W. end is 3 miles W. of Mifflinsburg. Jack's Mountain anticlinal passes its S. side, and the White Mountain anticlinal its N. The Scalent and Pre-meridian limestones are quarried on the N. side at Mifflinsburg, and at many other points along both sides and at the W. end, whence lime is hauled to the extreme head of the valley, even for farms, close by which run the outcrops of the older ore shale with its bed of pure limestone.

Hæmatitic ore, in large masses, occurs in the S. side of Dale's Hill, 4 miles from Lewisburg. A hole 60 feet deep was sunk without touching solid rock, but without meeting ore.

Lead.—Galena has been found in thin lodes traversing the calcareous spar-veins in the limestone ; but no workable vein has ever been discovered.

The Cadent Black Slate.—This formation, crossing the river at a single point, penetrates to the E. end of Dale's Hill. It may be studied half a mile N. of Lewisburg. The strata are almost horizontal, and when thoroughly wet resemble coal-slate, being smooth and black, and they have accordingly been explored for coal. They are highly calcareous, resting, in the absence of the Meridian sandstone and slates, almost directly upon the Pre-meridian limestone. They are also abundantly pyritous. Upon the low ridge along the outcrop of these shales, S. of Hummel's and Shaffer's farms, nothing will grow ; nor is the poisonous influence of the sulphuret of iron obviated by any ordinary manure or lime. The Pre-meridian limestone layers nearest the slate also contain the pyrites.

This point of black slate, E. of the river, spreads so as to underlie an extensive level sandy area, and there it bifurcates to pass along the N. and S. sides of the Mahanoy or Chillisquaque Ridge. The extension E. of Dale's Hill is synclinal.

DIVISION III.

THIRD BELT OF THE SIXTH DISTRICT, OR THE COUNTRY EMBRACED BETWEEN JACK'S MOUNTAIN AND SIDELING HILL ON THE SOUTH-EAST, AND BALD EAGLE, DUNNING'S, AND WILLS' MOUNTAINS ON THE NORTH-WEST.

CHAPTER I.

GENERAL STRUCTURAL FEATURES OF THE DISTRICT.

THE reader will be materially assisted in his study of the somewhat intricate geology of this interesting portion of the mountain-chain, if, before entering upon our detailed description, he will give his attention to the following concise general sketch of its leading structural features.

This North-western half of the Appalachian Chain of the State has all its geological and topographical features so intimately bound together as to render it expedient that we treat it as one natural zone. Thus viewed, it will be found to traverse the State obliquely from the Susquehanna to Maryland, bordered everywhere on the N.W. by the natural limit of the escarpment of the Alleghany Mountain, and on the S.E. by a long slender strip of Middle Palæozoic rocks, chiefly Cadent, in a continuous valley from the head of the Wapwallopen to the Potomac at Hancock. Structurally regarded, its central portion, or that situated between the Lewistown Valley and the Alleghany Mountain, consists of ten great parallel compressed waves of the strata, the lowest of which are the bottom rocks of the Auroral, and the highest the middle beds of the Surgent series. Its terminal portions have a different structure. By virtue of a relative shortness of the middle ones of these ten undulations, each extremity of the belt forks, as it were, into two long anticlinal prongs, and admits a synclinal trough of all the upper rocks, including the coal-measures within the bifurcation. Thus, in place of the ten flexures seen in Mifflin and Centre or Union and Lycoming counties, W. of the North Branch, there remain, when we advance E. as far as Fishing Creek, but two chief ones, the axis of Montour's Ridge, and that between the Shickshinny and North Mountain, and but one main synclinal trough, the Western end of the Wyoming Basin. Again, in the S.W. direction, the same central group of ten or more flexures resolves itself into two dominant anticlinals, those respectively of Jack's Mountain and Canoe Valley, with one wide synclinal basin between them, that of Trough Creek in Broad Mountain. As, toward the NE., the Northern prong of the fork is the longest, widest, and most complex, from the presence of lesser flexures, so likewise in the South-western bifurcation, the North-western prong is altogether the largest, extending the whole way to Maryland, but including always two and sometimes three anticlinals. The entire zone may be likened roughly to the doubly-forked stick or needle upon which twine is often wound. Let us now trace, in systematic order, the range and distribution of the chief flexures which constitute this curious anticlinal zone, and their relations to the prominent external features of the district.

Anticlinal Axis of Montour's Ridge.—An important flexure, the most Southern of the Eastern end of the district, ranges from near the sources of the Lehigh E. of Wilkesbarre, through the table-land of the Vespertine rocks, encircling the head of the Wapwallopen Valley, and thence along the descending bed of the little Wapwallopen Creek, and across the Susquehanna to the Eastern point of Montour's Ridge, the central crest of which it follows to the West Branch of the Susquehanna, beyond which the axis expires at the distance of a few miles in the Surgent shales of Union County, in the Valley of Turtle Run. The lowest rocks lifted to view on the most denuded portion of the back of this very regular straight wave, are the upper members of the Levant white sandstone. These barely peep to the day in a ravine opening to the Susquehanna, at the Danville Narrows. This flexure is a very regular one, being not only straight, but, throughout most portions of its length, of unbroken and uniform arching. It is of the normal type, steepest on its N.W. flank. Local irregularities do occur in it, especially near Hemlock Creek, which, however important in spreading the fossiliferous iron-ore over a wide accessible outcrop, are of trivial magnitude when estimated by the length and breadth of the entire wave.

Anticlinal and Synclinal Axes of Kishacoquillas and the other Limestone Valleys of Union, Mifflin, Centre, Blair, and Bedford Counties.—Nearly in the prolongation of the anticlinal flexure which contains Montour's Ridge, rises the central anticlinal axis of Kishacoquillas Valley. This interesting tract, a more detailed description of which will be presented in a future chapter, is a compound valley of elevation and erosion, forking North-eastward into three prongs, and South-westward into two. Each prong or branch is merely the deeply denuded back or crest of an anticlinal wave, cut by the denuding waters to a deeper level than the intervening more protected synclinal portions, which stand up as so many mountain plateaus. The erosive currents, trimming down and removing the strata in proportion to their relative softness, and their degree of exposure to the wearing action, have not only scooped out the crest of the anticlinal waves, but shaped their sides and the troughs between them into singularly regular terraces upon the sides of the mountain-ridges. The bed of the valley and of its branches exposes the Auroral limestone and Matinal shale, both of them soft and easily excavated materials, especially before they were hardened by the agencies which uplifted them, and discharged the sea from above them. The sides of the valley and of its coves consist of the Levant sandstones, a much more resisting group of strata than the Matinal and Auroral. The Levant grey sandstone forms the general elevated terrace which encircles the whole at nearly one constant level, and the Levant white sandstone the upper crest which overlooks the shelf, the intermediate softer Levant red sandstone and shale the floor of this shelf itself.

At the head of each anticlinal cove, the two bounding terraces unite and form a broad elevated mountain-floor, which is itself only a higher cove or great step above the lower one, and this is encircled in its turn by the converging and uniting of the still higher ridges of the Levant white sandstone. Such is the topographical structure exhibited by each interior anticlinal cove, or narrow valley, near its termination. Exterior to these coves, the configuration of their enclosing mountains is just the reverse of this. Buffalo Valley, in its general features and structure, is a comparatively smooth undulated synclinal tract, while the region of Kishacoquillas, Penn's, and the other limestone valleys, is anticlinal and rough. The mountain-spurs

Russell Smith

KISHICOQUILLAS VALLEY, FROM BAIRDS KNOB. *Looking S.W.*

Russell Smith

BLACK LOG, AND SHADE M^{TS} FROM MIFFLINTOWN

which penetrate it are all anticlinal, and the re-entering coves synclinal, whereas in the interior district the spurs are all synclinal, and the coves anticlinal. It is obvious, then, that tracing any one axis or crest-line of the ten great anticlinal waves, which together constitute this wide undulated zone, we are led, as the wave ascends and widens, from the exterior plain of Union County first into a terminal mountain-spur, next, by the forking of this broad rounded summit, into a mountain platform, or high floor, enclosed between the two narrow monoclinal crests into which that high rounded summit has subdivided, and then down into a lower cove or valley between sloping mountain-walls, formed by the forking in its turn of the platform just passed over. This general sketch of the successive phases presented by the anticlinal flexure, applies, it will be observed, with equal accuracy to all the undulations of this portion of the mountain-chain, for they all embrace precisely the same geological conditions—namely, the presence of the three Levant sandstones, a middle member, soft and readily excavated, between two harder and more resisting ones.

Let us now take up the larger individual flexures of the district, and trace briefly their axis lines, as these have been patiently observed and mapped in the field operations of the Geological Survey, observing our accustomed order of description.

Anticlinal Axis of Moser's and Swartzel's Valleys.—The first or most South-eastern of the remarkable group of ten anticlinal flexures of the mountains S.W. of the West Branch, is that which forms the Southern spur or prong of Jack's Mountain in Union County. This wave of the strata originates in the neighbourhood of New Berlin, from whence we may trace the axis-line or crest of the wave the whole way to the mouth of Swartzel's Valley in Kishacoquillas. It curves very regularly, and gently Southward, as it stretches W. Between Penn's Creek and Moser's Valley it is marked by a range of low ridges of Cadent sandstone. In Moser's Valley it lifts Pre-meridian limestone, and from between this the soft Surgent rocks, and then enters the spur of Jack's Mountain, through which, and the high terrace W. of it, it ranges almost centrally until it enters Swartzel's Valley, where the wave, becoming sharper, and its N.W. flank steeper than its S.E. one, the axis-line follows the N.W. margin of the cove till it passes Beattie's Knob. The flexure seems to die out in Kishacoquillas Valley before it reaches the East Branch of the creek of that name. No trace of it can be detected near the turnpike road. The shortness of the mountain-spur which it elevates is in proportion to the limited range of the flexure S.W.

Anticlinal Axis of the Main Spur of Jack's Mountain, or Main Axis of Orr's Valley.—This line of flexure originates S. of Montour's Ridge, crosses the West Branch 3 miles above Northumberland, and ranges thence through the crest of Longstown Ridge until it reaches the pass of Penn's Creek through the end of Jack's Mountain. Ascending this spur, it traverses next the middle of the high plateau of Jack's Mountain and enters Orr's Valley, the North-western border of which it follows until this cove merges into the broad plain of the Kishacoquillas Valley, where, curving somewhat more rapidly to the S.W. than before, it ranges on, passing Perryville, until it encroaches on the base of Stone Mountain, to which it runs nearly parallel until it ceases at the foot of the mountain, about one mile N.W. of Belleville. The sweep of this flexure is very regular from the Susquehanna to the wide part of Kishacoquillas Valley, but it there inflects more rapidly South-westward for 3 or 4 miles, until it passes Baird's Knob; beyond which, to its termination, the axis is nearly straight. At its origin E. of the

Susquehanna, it lifts the Cadent rocks, then W. of the river, the Surgent series in Longstown Ridge, the Levant sandstones in Jack's Mountain, and finally, the Matinal and Auroral formations in Orr's and Kishacoquillas valleys. In the last-named district, the N.W. flank of the wave is actually inverted or doubled past the perpendicular under the S.E. one.

Subordinate Axis of Orr's Valley and Perryville.—A second anticlinal flexure is traceable through the limestone of Kishacoquillas Valley, from the centre of Orr's Valley, a little above its mouth, South-westward past Perryville, to the vicinity of Belleville. It ranges parallel with the main axis at an average distance from it of not more than one-third of a mile. Its N. dip is far less steep than that of the main flexure, upon the S.W. slope of which it forms but a secondary undulation. The two flexures expire in the same vicinity in the broad tract of Matinal slate N.W. of Perryville, before they reach the great dislocation which jogs the crest and terrace of Stone Mountain.

Anticlinal Axis of Buffalo and Christman's Valleys.—This interesting undulation of the rocks begins probably E. of the Susquehanna, not far from the N.W. foot of Montour's Ridge. It crosses the river S. of Lewisburg, and, with a very gentle symmetrical curvature South-westward, courses centrally along Buffalo Valley to the knob called "White Mountain," through the crest of which it passes into the elevated terrace encircling Christman's Valley, and then takes the N.W. border of this valley to the head of its Southern cove, where the axis-line passes another mountain-terrace, and still loftier mountain-spur, called the "Broad Mountain" of the group of the Seven Mountains. Passing out of this high knob, it descends into Stone Valley, and expires in a broad rolling plain of Cadent strata watered by Stone Creek. This beautifully-regular anticlinal wave, terminating at both extremities in the Cadent rocks, barely lifts the Auroral limestone to the surface in the middle of Christman's Valley, from which culminating neighbourhood its crest-line descends much more rapidly South-westward than North-eastward.

Anticlinal Axis of Jack's Mountain of the Juniata.—An important anticlinal flexure arches the strata throughout all the S.W. half of Kishacoquillas Valley, and throughout Jack's Mountain to its termination. The anticlinal axis of this wave is first seen W. of Brown's Gap, nearly in line with that of Swartzel's Valley, with which, however, it would appear not to be continuous. It ranges almost absolutely straight through the centre of the valley for more than 12 miles to the foot of Stone Mountain, where, taking an abrupt bend Southward, it follows the base of this ridge to the head of the cove in which the valley ends: thence maintaining a new and nearly straight course, it pursues the crest of Jack's Mountain across the Juniata, terminating S. of that ridge in the Great Aughwick Valley. This flexure must be regarded as the S.W. half of the main undulation of Kishacoquillas Valley, a little dislocated in line from the North-eastern portion of the wave which traverses Orr's Valley. Upon this view, the general flexure terminates at both extremities in the Cadent or higher rocks. The abrupt displacement of the crest-line of this main wave of the Kishacoquillas Valley is obviously connected with the oblique fracture of the strata, indicated by the fault through Stone Mountain W. of Belleville.

Anticlinal Axis of Po Valley.—A regular but shorter anticlinal wave lies N.W. of that of Christman's Valley, at about the average distance which separates the three Eastern flexures of Kishacoquillas. This is the anticlinal of Po Valley. It is first detected in Buffalo Valley N. of Buffalo Creek, and W. of the Lewisburg limestone ridge. Ranging centrally through the knob called Paddy's Mountain, it traverses first the mountain-terrace behind this, and then the middle of Po Valley, where the lowest rock which it lifts to the day is the Matinal shale. From the S.W. end of Po Valley, it takes a nearly straight course along the table-land of the Seven Mountains, where it is the axis which separates the third and fourth ridges of the seven visible at the turnpike. It leaves the Seven Mountains through a short spur which protrudes into Stone Valley, and takes thence the middle of that valley until it enters a cove between the limestone ridges E. of Ennisville. It seems to expire S. of this village somewhere in the table-land of Warrior Ridge. This flexure, though of considerable length and breadth, is a wave of small elevation compared with the chief ones S.E. and N.W. of it.

There is a subordinate anticlinal flexure in the Seven Mountains, dividing the fifth and sixth monoclinal crests of that region, which we may regard as a secondary wave on the N.W. flank of this main flexure of Po Valley. It and the other subordinate undulations will be mentioned in more detail hereafter in their appropriate connection.

Anticlinal Axis of Penn's Narrows.—The fifth principal flexure of the district originates, like that of Po Valley, in the plain W. of the Susquehanna. It probably commences N. of the Lewisburg limestone ridge. Ranging South-westward with the gentle curvature which belongs to the most regular of the series, it enters the mountain-knob which lies between Paddy's Mountain and Penn's Knob, and, pursuing the middle of the plateau enclosed by the forking of this spur, it follows the middle of the cove of Penn's Valley called "Penn's Narrows" to its mouth. From Penn's Narrows, the axis-line, now curving somewhat more rapidly South-westward, runs near the foot of the Seven Mountains all their length through the middle of George's Valley and the cove called the "The Loop," where it passes through the terrace and knob of Tussey's Mountain at the Bear Meadow. There the flexures begin to subside rapidly South-westward, and the anticlinal axis descending through a long middle prong, in which the mountain-spur terminates, passes down and ceases in the valley of Shaver's Creek, or, more truly, in the Warrior Ridge south of Mooreburg. This wave in the strata shows a less vertical rise between its extremities and its centre, than some of the longer ones previously described ; for, dying away at both ends in the Surgent rocks, it barely lifts to the day the upper part of the Auroral series in its middle portion between Penn's Narrows and The Loop.

Anticlinal Axis of Penn's Valley.—The main or North-western anticlinal of Penn's Valley probably originates E. of Milton, N. of which town it crosses the Susquehanna. It is, in all likelihood, the chief, if not the sole, anticlinal of the limestone ridge W. of Jerseytown ; and upon this view, it must rise near the S. side of the wide compound anticlinal belt of Cadent and Vergent rocks N. of the Knob or Shickshinny Mountain, running from the Susquehanna with a soft uniform sweep toward the S.W., to attain an almost perfect parallelism with the crest-lines of the flexures already traced. It traverses first the plain of Union County in Surgent strata to the mountain-spur called "Penn's Knob," where, like the rest in similar position, it lifts the Levant sandstones, dividing first the upper or white member, then the middle or red, and then the lower or grey. From the mountain-terrace supported by the latter it enters Penn's Valley Cove, ranges along the N.W. edge of this at the foot of Brush Mountain, and thence out into the main Penn's Valley, passing half a mile N.W. of the foot of Egg Hill, and so onward into the indentation or cove in Tussey's Mountain between its two synclinal spurs. It not improbably passes through Tussey's Mountain, and dies out in Shaver's Creek Valley in one of the narrow spurs descending into it from the main ridge. Like several of the undulations S. of it, this flexure subsides from its district of greatest elevation of crest, which is Penn's Valley, much more rapidly South-westward than North-eastward. Its deflection or curvature on a horizontal plain is likewise most rapid towards its S.W. end. The transverse profile of this wave displays throughout the greater part of its length a considerably greater steepness of its N.W. dips, compared with its S.E. ones.

Anticlinal Axis of Brush Valley.—This seventh flexure of the series rises N. of the preceding, in the Cadent rocks somewhere E. of Fishing Creek in Columbia County, and, gradually ascending, produces the second promontory of limestone, counting Northward, in the valley of the Chillisquaque Creek. Passing centrally through this, and through the Surgent marls and shales, it crosses the Susquehanna north of New Columbia, and presently enters the high spur called "Buffalo Mountain." From this spur it ranges along the high terrace encircled between its monoclinal branches, and enters the head of the long cove in which Brush Valley commences. It takes the Northern side of this cove, and of Brush Valley proper, the whole distance to the meridian of Boalsburg, opposite the end of Nittany Mountain. W. of Boalsburg the flexure rapidly subsides, and it probably expires before it reaches the Northern base of Tussey's Mountain, which it very obliquely approaches. This extensive wave of the crust exhibits still more strikingly than its predecessors to the South an increase in its rates of Southward curvature, and of subsidence of actual level after it attains its greatest vertical elevation, which is near the end of Brush Mountain.

Anticlinal Axis of Little Valley, or Whitedeer Creek.—Side by side with the previously described wave rises another, the eighth of the series, which, traversing centrally the anticlinal belt N. of the Shickshinny Mountain, takes the middle of the third small limestone belt crossed by the Chillisquaque, and runs thence across the Susquehanna, a little S. of Watsonburg and Whitedeer Creek, until it enters the mountain-spur which lies between the knob called "Buffalo Mountain" and another called "Whitedeer Mountain." From this knob, which subdivides precisely, as all the rest do, the anticlinal axis ranges centrally along the mountain terrace, and through the middle of the narrow valley we have designated as the Little Valley. After elevating to the surface the Matinal limestone in the centre of this mountain glen, the crest of the wave passes out by its Western extremity into the middle of the broad table-land of the Nittany Mountain, separating Brush Valley from Sugar Valley, and it there soon flattens away, expiring very rapidly South-westward, like nearly all the others, after passing its culminating point.

Anticlinal Axis of Sugar Valley.—This is undoubtedly the Northernmost of the four anticlinal flexures which, E. of Fishing Creek and N. of the Shickshinny Mountain, spread the Cadent and Vergent rocks in the wide and long undulating belt they there occupy. After traversing those strata for many miles, the crest-line or axis of the wave enters the point of Pre-meridian limestone W. of Whitehall, and then lifts the Surgent strata till it reaches the Susquehanna, which it crosses between Watsonburg and Union Town a little S. of the mouth of Whitedeer Hole Creek. Beyond the river, still rising, it ascends along the crest of Whitedeer Mountain to where this divides, past which it takes the middle of its enclosed mountain-terrace, and then the N.W. side of Sugar Valley the whole way to its opposite extremity, where the axis once more traverses terrace and mountain-knob to its termination in the broad table-land called "Pheasant Valley." This axis has a rather greater degree of inflection or convexity towards the N.W. than any of those S. of it, and it owes this feature to the subsidence of the wave of the Little Valley adjoining it opposite the central part of its own length, or the middle of Sugar Valley. Like all the others, it flattens away much more rapidly South-westward than North-eastward.

Main Anticlinal of Nittany Valley.—We come now to the tenth or last of the series of great anticlinal waves which cross the W. branch of the Susquehanna, and culminate in Mifflin and Centre counties. It is by far the grandest undulation of the group, transcending all the rest in length, and rising, in its central portion, to a higher absolute level along its crest. The total length of this great wave is, approximately, 130 miles. Its amplitude, measured from the main synclinal axis S.E. of it to the synclinal centre of the first coal-basin on the Alleghany Mountain, is not less than from 15 to 18 miles; and the actual vertical height of the wave, estimated by the difference of levels assumed by the base of the Auroral series on the axis in Nittany Valley, and the same strata under the centre of the first coal-basin, is as much as 20,000 feet. If, in other words, the coal rocks which once spanned this mighty wave were now in the position from which they have been stripped by the powerful cutting action of violent currents of water, they would rest perpendicularly over the anticlinal axis of Nittany Valley at the prodigious altitude of 4 miles.

The first appearance or Eastern rising of this wave is in the Mahoopeny Mountain, where it insulates the patches of the coal conglomerate of the Alleghany plateau from others pertaining to the Loyalsock coal-basin. The axis or crest-line of the flexure passes Westward through the head of the cove, separating the knob called the North Mountain from the Bald Mountain, or the main table-land. Approaching the Susquehanna, it lifts the Pre-meridian limestone, and W. of this all the Surgent rocks, to the surface, and then crosses the river about a mile N. of Pennsborough. Gradually deflecting a little S. of W., it follows the long ascending crest of the Muncy or Bald Eagle Mountain, ranges a little N. of the middle of the table-land which this embraces, and runs through Musquito and Nippenose oval valleys a little N. of their centres. Still bending steadily Southward, it enters the head of Nittany Valley, and ranges with remarkable continuity of line the whole length of this great cove, at a distance of about 1½ miles from the crest of the Bald Eagle Mountain, with which it maintains a remarkable parallelism as far as the Little Juniata. From the vicinity of Mill Hall Gap to that of Tyrone Gap, the axis-line is almost straight, but near the latter meridian it observes a slight bend Southward, and, inflecting more and more S., it ranges through the head of Sinking Valley and the knob of Brush Mountain, and out into the plain watered by the Upper Juniata, where it passes the Western edge of the town of Hollidaysburg, and runs on to its termination in the Vergent rocks a few miles S. of Newry. Throughout its entire length the S.E. slope of this great wave exhibits a moderate or normal degree of inclination, but the N.W. flank is excessively steep, and all along the middle and South-western part of its course from Nittany to Sinking valleys it is perpendicular, and even overturned; and not merely overturned, but dislocated from the S.E. side of the wave by an enormous fault or down-throw, the cause of the unusual straightness.

Anticlinal Axis of the S.E. Side of Nittany Valley.—There is a subordinate anticlinal flexure ranging along the Southern side of Nittany and Half-Moon valleys, the whole way from a point E. of Bellefonte to the mouth of Warrior Mark Run, E. of Canoe Mountain. The crest-line of this undulation is even straighter than the dislocated part of the great one, with which it is very nearly parallel. Towards its Eastern end it laps past the Western extremity of the anticlinal of Brush Valley, and the two include between them in their synclinal trough a strip of the Levant sandstones, constituting the long tapering spur of the Nittany Mountain. The Western half of the flexure has no opposing wave S. of it, and therefore Tussey's Mountain, which next adjoins it, is monoclinal.

There is no reason to infer that the flexure here described prolongs itself, by a sudden bend near the Little Juniata, into the great anticlinal of Canoe Valley and Morrison's Cove, but fair ground for believing that, as axis-lines, they are disconnected, though of course the two waves are to be regarded, in a general sense, as parts of one grand flexure warped along its crest, and abruptly bent in the obviously dislocated neighbourhood of the Little Juniata, where the two axis-lines approach.

Flexures S.W. of the Little Juniata.—*Anticlinal Axis of Canoe Valley.*—The flexure above alluded to, of Canoe Valley, starting N.E. of the Little Juniata, opposite or W. of the place of ending of the South-eastern axis of Nittany Valley, in Warrior Mark, extends, with a nearly straight crest-line, obliquely through Canoe Valley and Morrison's Cove, encroaching gradually on Tussey's Mountain until it enters the cove formed by the loop of this ridge N. of Yellow Creek, where it passes through the spur of the mountain, to die away in Woodcock Valley. Like all the rest, this wave of the rocks curves gently towards the Meridian in its course to the S.W.; indeed, near its termination it tends almost S. It is truly but the S.W. half of the second or South-eastern axis of Nittany Valley, warped out of line, like the main flexure of Kishacoquillas Valley, by transverse dislocations of the crust. A subordinate flexure arches the strata in the Eastern side of Morrison's Cove opposite Williamsburg, and produces a loop or cove in Tussey's Mountain. It would appear not to be a continuous wave, but a warp or fold on the S.E. slope of the main undulation, converted with a prodigiously violent transverse wrenching of the strata, for which there is ample independent evidence in the great cross-fracture through the crest of Canoe Mountain.

Anticlinal Axis of the W. Side of Morrison's Cove.—Another important wave, steeper, but shorter than that of Canoe Valley, ranges along the Western side of Morrison's Cove from the anticlinal knob of Lock Mountain to the spur which looks into the middle of Dutch Corner. This flexure originates near Frankstown, and ceases N.E. of Bedford. It is dislocated along its anticlinal axis, and its Western slope is therefore vertical, and in some places overturned, with possibly some amount of down-throw. To this we may impute the unusual style of curve of the axis-line, and of the crest of Dunning's Mountain, which are slightly convex towards the E., and not, like nearly all the others, towards the W. or N.W. A short diverging flexure or warp in the strata passes off from this main axis, and ranges through the S.W. spur of Dunning's Mountain, to die away in the Bucktown Valley. Such a forking of an anticlinal flexure is seldom observed but where one of the two, generally the chief or crest axis, is also a line or plane of dislocation.

Another anticlinal axis, the middle one of the three principal flexures of the S. end of the cove, runs Southward from near the centre of the valley passing W. of Woodberry, to the Southern loop formed by the approach of Tussey's and Dunning's mountains. Here it seems to expire, for the main axis of Snake Spring Valley and Friend's Cove, though nearly in prolongation, is not at all in line with it, and manifestly belongs to a different group of waves.

Anticlinal Axis of Friend's Cove.—The beautiful slender valley of elevation and erosion called Friend's Cove and Snake Spring Valley, contains a double wave, or the double crest of one broad flexure, of which its strata are but the undulated summit. One of the axes extends from the head of Snake Spring Valley to the S.W. nook of Friend's Cove, and along the crest of Evit's Mountain to Maryland. The other originates 2 or 3 miles N. of the Juniata (the Raystown Branch), and, following the Eastern side of the valley as the first does the Western, issues from it through a wide cove in the W. flank of Tussey's Mountain, and takes thence the crest of that ridge to the Maryland line, making, with the Western axis, the synclinal trough of Bean's Cove. The Western or main flexure, like the similar one of Morrison's Cove, and the North-western or chief wave of Nittany Valley, is a line of dislocation, and, as a consequence, the strata of its W. flank, well seen in Evit's Mountain, are perpendicular, and even inverted.

Anticlinal Axis of Milliken's Cove and Wills' Mountain.—This beautifully straight flexure of the normal type rises N. of the Juniata near Buckstown, ranges through the point and crest of Wills' Mountain west of Bedford, follows the Western edge of Milliken's Cove, re-enters Wills' Mountain, where its two monoclinal crests coalesce, and pursues its central ridge to the Potomac, and into Virginia. Like all the Western flexures of the group, this wave is much steeper in its Western than in its Eastern slope. The vertical attitude of its Westward-dipping strata is well displayed in the contrast between the two monoclinal ridges bounding Milliken's Cove, the more Western being low, slender, broken, and deeply notched in three places; the Eastern, on the contrary, being a lofty, massive, and continuous mountain. These features are shown in the picture sketched from Day Ridge, inserted in the Chapter on Mountain Scenery.

We pass now to an account of the formations.

CHAPTER II.

CHARACTER OF THE FORMATIONS.

In the territory now before us, nearly all the formations occur on a very expanded scale. Indeed, this region, and its extension S.W. through Blair, Huntingdon, and Bedford counties, presents us with all the three Lower Palæozoic series—the *Auroral, Matinal,* and *Levant,*—in greater thickness and diversity of composition, and in more satisfactory exposures, than any other quarter of Pennsylvania.

The Auroral and Matinal Rocks undergo no material changes within the limits of the district we are considering, nor, indeed, do we notice any very essential alterations in their composition or dimensions when they are compared with the same formations exposed in the Great Kittatinny Valley. Consisting for the most part of oceanic precipitates, we ought not to look for any very marked differences within a space which, after all, constitutes so small a part of the vast area over which those deposits are spread. As might be anticipated, the coarser rocks of mechanical origin, the Matinal slates, exhibit the greatest amount of apparent change as we trace them towards the N.W. As this district is the only portion of Pennsylvania where all the strata of the Auroral and Matinal series are clearly presented for study, undisguised by that excessive amount of folding and cross cleavage which so obscure their order of superposition, and their fossils, in the Kittatinny Valley, I shall take this occasion to enter into a general description of the several formations as they occur here, observing as usual the ascending order.

The Auroral Magnesian Limestone.—This, the lowest exposed formation in the region, occupies by far the greater part of the surface of all the principal valleys, extending from the anticlinal axis in Kishacoquillas, Nittany, and the other valleys, to within a few hundred yards of the base of the encircling ridges. It is a formation of amazing thickness, though the whole mass has not been measured.

The underlying primal rocks not appearing along any of the anticlinal belts, we remain uncertain as to how much of the magnesian limestone lies beneath the lowest outcrop upon each axis. Judging from the external signs of the presence of extensive subterranean caves in these situations, the unexposed thickness of the rock is probably many hundred feet. The line along which the formation has been most fully brought to the day, is the great anticlinal belt of Nittany Valley and Morrison's Cove. In Kishacoquillas, and the other minor valleys, the extent of vertical elevation in the axis having been much less, the upper half only of the formation is in view.

In Nittany Valley, the Auroral magnesian limestone consists, as usual, of an alternation of thick bodies of two principal varieties of magnesian limestone. One of these is a rock of a rather dark, dull-grey aspect, and a crystalline or granular internal structure. Its weathered surface is peculiarly harsh and sandy to the touch—not so much from the presence of silicious sand, as from the disintegration of the minute crystals which compose it. This variety is decidedly ferruginous—iron, in the condition probably of a carbonate, existing in it very usually, and manifesting itself in the ochreous soil which very generally overlies the rock. To this portion of the limestone I would trace much of the iron ore of these great calcareous valleys.

The other portion of the formation is a remarkably smooth and fine-grained rock of a very pale-blue colour, or rather of the tint called French grey. It is very uniform in its texture, and consists apparently of excessively comminuted particles, that have cohered into rock from the condition of an impalpably fine pulp. It is highly magnesian, the weathered surfaces being coated with a white crust, composed of carbonate of magnesia and lime. Some of the beds contain numerous small white knots of crystallised dolomite, another proof of the abundance of the carbonate of magnesia in its composition.

Besides these two varieties, there alternate with them in the upper part of the formation some thinner masses of a non-magnesian limestone, of a clear and rather dull-blue colour. Of the two chief rocks described, the darker and more crystalline sort constitutes much the largest portion of the whole formation, predominating greatly in the middle and lower strata.

The total thickness of the formation visible in the Nittany Valley, in the vicinity of Bellefonte, considerably exceeds 5000 feet.

A careful examination discloses the following subdivisions in ascending order,—

FIRST, *Non-fossiliferous Portion.*

(*a*) Grey crystalline magnesian limestone, which, though exposing a thickness of 600 feet, is evidently thicker, the still lower strata nearer the axis being badly exposed for measurement—no fossils, about	.	600 feet.
(*b*) Light-blue magnesian limestone—no fossils,	.	700 „
(*c*) Grey crystalline magnesian limestone—no fossils,	.	1500 „
(*d*) Light-blue limestone—fossils (very rare),	.	300 „
(*e*) Alternation of light-blue, fine-grained, and dark-grey crystalline rock—corallines,	.	1000 „
(*f*) Light-blue massive magnesian limestone—no fossils,	.	500 „
(*g*) Alternation of argillaceous blue limestone and grey coralline magnesian variety,	.	200 „
	Thickness,	4800 feet.

SECOND, *Fossiliferous Division* (Black River group of New York).

(*h*) Blue massive and thin-bedded limestone, some layers speckled with spar and filled with holes, caused by the removal of a coral—has many of the fossils of the formation,	.	400 feet.
(*i*) Lighter blue, fine-grained rock, identical in texture with the "bird's eye" limestone of the Mohawk—Cytherina and other fossils,	.	150 „
(*j*) Massive fine-grained blue rock, weathers in holes from an obscure coral,	.	20 „
(*k*) Thin-bedded encrinal and coralline rock,	.	30 „
	Thickness,	600 feet.
	Total,	5400 feet.

Organic remains in this prodigiously-expanded portion of the Auroral series are extremely rare, and the better-defined forms are all restricted to the upper half of the mass. The most distinctive form is a coralline of obscure structure, which abounds in some of the finer-grained strata, imparting to the more weather-eaten surfaces a pitted structure resembling worm-holes. Two or three univalve shells have likewise been met with many hundred feet below the highest beds of the formation. These, which are chiefly specimens of *Pleurotomaria*, being abundant in the next superior subdivision of the formation, serve sufficiently to tie together the upper and lower members of the mass. At the same time, the abrupt appearance of a great variety of genera for the first time, as we ascend above the horizon of the non-fossiliferous division, and the striking and permanent change of lithological and chemical characters in the rocks, are ample reasons for subdividing this enormous mass of strata. The transition from the almost non-fossiliferous portion of the magnesian limestone to the overlying fossiliferous rock is well seen in the bank of the Bald Eagle Canal, about half a mile above the town of Bellefonte, and also in Kishacoquillas Valley, near the head of the dam at Brown's Mill.

Matinal Limestone (Trenton Limestone of New York).—This mass, while it demands insulation from the other or Auroral limestone, in consideration of its organic remains, is yet not very clearly separable in the region now before us. It is not practicable to discover a sharp line of division between the two groups, either by the fossils which respectively characterise them, or by their lithological features ; and to attempt arbitrarily to fix their limits would therefore be worse than idle. The boundaries assigned them are to be regarded as rather conventional than absolute. The horizon, which, for convenience sake, is here selected as the beginning of the Matinal limestone, is the base, or, in ascending order, the commencement of the dark-blue somewhat carbonaceous limestone, in which we first meet with *Orthoceras pressum* and *Lingula Trentonensis*, and where the *Isotelus gigas*, previously rare, grows abundant, and the *Cytherina* altogether disappears. This rock, which is certainly the typical deposit of the formation, alternates throughout with light-blue and grey thin-bedded very fossiliferous layers, and in the middle and higher portions contains some thin seams of dark-blue shale. The entire formation measures in Kishacoquillas Valley about 550 feet, and in Nittany and Nippenose valleys from 300 to 400 feet. In Kishacoquillas the passage from the limestone to the overlying Matinal black slate, well seen near the tavern at Brown's Mill, is very abrupt, but in Penn's and Nittany valleys it is less so, and in Nippenose it is indeed rather gradual.

Matinal Black Slate (Utica Slate).—This deposit maintains its distinctive features throughout this region, and indeed every part of Pennsylvania, where it outcrops with less variation, perhaps, than any of the other Matinal formations. It is a very dark-blue carbonaceous slate and shale, being usually extremely fissile in its lower beds, except in localities where the strata are affected by oblique cleavage, when this characteristic structure is of course more or less disguised. In the region before us, it contains, though nowhere in profusion, the chief characteristic fossils by which it is elsewhere recognised.

In Kishacoquillas Valley these are greatly obscured, the sedimentary surfaces being obliterated by an extensive cross-cleavage; but in Nittany Valley, at Bellefonte, and other places, they are to be readily found. In the first-named valley, the whole thickness of the formation is about 400 feet, and in the last, or more North-western, it is about 300 feet.

Matinal Shales (Hudson River Slate).—Throughout the entire region before us, this uppermost of the Matinal formations maintains its prevailing Northern type, consisting of blue and greenish-grey shale, alternating with grey, calcareous, and argillaceous sandstone in thin beds, in which lie most of its characteristic fossils. The sandstone layers grow progressively more abundant as we ascend in the formation. It is worthy of remark, that high in the mass we find, among many fossils restricted to this formation, quite a number of species which are common in the Matinal limestone, and which elsewhere are even characteristic of that rock. These species, therefore, after having vanished for a time from this part of the bed of the ancient ocean, while it was in possession of the races contemporaneous with the black-slate deposit, reappeared and rapidly multiplied as soon as the period of that sediment was over.

The whole formation seems to decline gradually in thickness as we advance N.W., being in Kishacoquillas Valley nearly 1200 feet thick, and in Nittany Valley not probably more than 700 feet.

The characteristic fossils of the Matinal strata of this belt will be learned by consulting the Chapters on the Palæontology of the State.

Levant Rocks.—In the district now before us, the eroding currents have extensively exposed the three great Levant formations—namely, the *Levant Grey Sandstone, Levant Red Sandstone,* and *Levant White Sandstone.* Neither of these undergoes much variation in its mineral characters or dimensions, the greatest change in these respects occurring with the Levant red sandstone.

Levant Grey Sandstone.—This formation, along the S.E. outcrops of the region, for example in Jack's and Stone mountains, consists of a light-grey, fine-grained, massive sandstone, with yellow ferruginous or ochreous specks. It is slightly argillaceous, and certain beds are very hard. Its thickness in Jack's Mountain is between 280 and 300 feet.

In the Bald Eagle Mountain, near Bellefonte, it includes two somewhat different rocks. The lower of these is the characteristic hard grey sandstone with yellow specks. This has a thickness of about 170 feet, and from its superior hardness, compared with the adjoining strata, is the rock which forms the edge of the bench or terrace in the Bald Eagle, and other similar ridges enclosing the limestone valleys. The upper member is a rather more argillaceous rock, being a greenish and grey slightly micaceous sandstone, marked, like the other, with ochreous yellow specks. Between some of the beds are thin layers of fissile yellow slate. This part of the formation is about 380 feet thick. The total thickness of the Levant grey sandstone, along this line, is thus about 550 feet. It would seem, therefore, to augment in thickness as it crosses the region towards the N.W. It contains no fossils except the marine plants commonly called Fucoids, and but very few of those.

Levant Red Sandstone.—In the mountains encompassing Kishacoquillas Valley, the Levant red sandstone presents a more diversified composition than where it outcrops more to the N.W. Thus, in Jack's Mountain, we find it consisting of two principal masses; the lowest, a pale red sandstone, imbedding numerous pebbles of white quartz and of Matinal slate, and of the harder Primal strata, is in reality a conglomerate. Its thickness at the Kishacoquillas Gap is 400 feet. Being a rather hard rock, and in massive beds, and possessing so considerable a thickness, it contributes, with the immediately underlying Levant grey sandstone, to the superior height and conspicuousness of the inner crests, or more properly the great terraces, which distinguish the mountains surrounding Kishacoquillas Valley, over the other similarly-constructed ridges of the district. The upper and more permanent member of the formation is composed, for the most part, of an argillaceous red sandstone, generally thin-bedded or flaggy, but containing, in the portion next to the underlying conglomerate, beds of a coarser and more sandy rock, imbedding thin layers of small quartz pebbles. Flat lumps and pebbles of red shale occur throughout the whole mass. This superior member of the formation measures, in Kishacoquillas Valley, from 500 to 600 feet in thickness. The total thickness of the Levant red sandstone, in the ridges enclosing that valley, is therefore between 900 and 1000 feet.

In the Bald Eagle Mountain, its most N.W. outcrop, the Levant red sandstone consists exclusively of thin-bedded grey and red argillaceous sandstone, alternating with about one-fourth of its amount of red, grey, and greenish shale. It imbeds few or no pebbles, and is not associated with any conglomeritic strata, such as underlie it in the ridges further to the S.E. It is to be considered, therefore, as the extension of the upper member only of the formation. A vertically-placed stem-like fossil, resembling an irregular *Scolithus*, is the only organic form discoverable in this rock. The total thickness of the formation in the Bald Eagle Mountain, at Bellefonte, is 500 feet. Thus we see that its dimensions grow less in crossing the district N.W., chiefly by the thinning-out of its lower conglomeritic division; and as the resistance which that massive rock opposed to the water is one principal cause of the prominency of the terraces in Kishacoquillas Valley, so its absence further N.W. is manifestly connected with the inferior distinctness of this feature in the Nittany and Bald Eagle ridges.

Levant White Sandstone.—In the region before us, this well-characterised rock experiences perhaps less variation in its composition and thickness than any other of the formations. With the exception of its terminating layers, it consists of massive beds of hard white and greenish-grey silicious sandstone. It is a finer-grained and more compact and homogeneous rock than the Levant grey sandstone, and contains few or no pebbles, such as impart to some portions of it, in the region of the Lehigh and Delaware, the structure of a silicious conglomerate. The uppermost beds very generally constitute a well-defined subordinate group of alternating sandstones and argillaceous slates ; the sandstones being hard, thin-bedded, and mottled red and grey, and often covered with a network of the impressions of obscure marine plants, especially the *Arthrophycus Harlani*, the slates being soft and greenish, and destitute of organic remains. The main body of the formation is a massive, fine-grained, hard, white and grey sandstone, sometimes yellowish, and thinly specked with ferruginous spots. The usual thickness of the whole formation is between 400 and 500 feet, the upper complex division measuring only 30 or 40 feet. The great hardness of the mass has placed it in the crests of all the monoclinal mountains of the district, and preserved it in the synclinal plateaus, where it forms very lofty summits, surrounded by terraces of the Levant red sandstone.

CAUSES OF THE PECULIAR STRUCTURE OF THE DISTRICT EMBRACED BETWEEN JACK'S AND BALD EAGLE MOUNTAINS.

To understand distinctly the origin of the very peculiar and beautiful structure of the region we are considering, it is merely necessary for the reader, with the Geological Map and Sections before him, to give his attention to the following circumstances, upon which depend all the features of the topography, and the distribution and range of the strata.

All the rocks of the district, viewed in connection with the causes which have given them their present outcrops, arrange themselves into two great groups : one, the Auroral limestone and Matinal slate, which, when first uplifted, were in the state of soft and pulpy clays and sediments, and easily torn by floods ; and the other, the Levant sandstones, which, being harder, coarser, and more cohering, opposed a greater resistance to the waters which scooped the surface. While thus unequally liable to destruction from the currents caused by the elevation of the strata, these rocks were disturbed from their original horizontal altitude by great subterranean forces, and thrown into wave-like flexures on a scale so vast, that in the entire breadth of this extensive tract they form ten grand parallel undulations or *anticlinal ridges*, and intervening *synclinal troughs*. The Geological Map shows the relative situation of these several waves, and the Sections exhibit their features of curvature. The waters, acting with destructive violence along these anticlinal belts, which, in the first rising of the crust, were alone exposed to their fury, swept off the exposed higher beds, but left the sheltered portions of the same strata in the synclinal troughs. As this denudation proceeded, it finally reached a stage where the Levant sandstones were all swept off from the much fissured and crushed convex or anticlinal waves, which stood like a series of shattered dams across the path of the impetuous surges. When these harder overresting strata were stript away, the whole region still rising through the waters, the underlying softer and more easily eroded Matinal slates and Auroral limestones came within the action of the currents, and were deeply and extensively excavated, while only those parts of the Levant sandstones were preserved which rested in the middle of each synclinal trough. But from the depth to which the floods cut down the Matinal and Auroral rocks along the anticlinal belts, these remaining tracts of the Levant sandstones lying in the synclinal troughs, were, from their less destructibility, left projecting above the general level in bold table-lands and mountain-ridges, so that those parts of the strata which were the troughs or zones of depression, became the higher tracts of the district. Such has been the origin of the broad synclinal ridges which jut forward from the E. into Kishacoquillas Valley, and likewise those of the Seven Mountains, Brush Mountain, Nittany Mountain, and of the synclinal chains of the region generally.

CHAPTER III.

KISHACOQUILLAS VALLEY.

TOPOGRAPHICAL DESCRIPTION.

Excepting the triangular tract of country bounded by Stone Mountain, Tussey's Mountain, and the Juniata, the whole wide area included between Jack's and Bald Eagle mountains is composed, as already said, of long and narrow parallel anticlinal valleys of the Auroral limestones and Matinal slates, bounded by straight and narrow synclinal mountain-ridges of the Levant sandstones.

Kishacoquillas Valley, the most S.E. valley of the series, lies between Jack's Mountain on the S.E., and the Seven Mountains and Stone Mountain on the N.W., and occupies part of Mifflin and Huntingdon counties. It is about 30 miles in length and 4 in breadth in the widest part. It is not straight, but curves gently in a crescent form, with the convex sweep N.W. From where the valley is widest, which is nearly opposite Brown's Gap, it slowly contracts S.W., by the converging of the bounding mountains, until it comes to a point within 4 miles of the Juniata. At its E. extremity, it becomes subdivided into three branches or subordinate valleys by the jutting forward of two broad and lofty synclinal ridges, the more Southern of which terminates in Beattie's Knob, and the more Northern in Stewart's Knob. The most Southern of the three little valleys, or that included between Jack's Mountain and Beattie's Knob, is called Swartzel's Valley, the middle and longest one bears the name of Orr's Valley, and the N. one, lying between Stewart's Knob and Seven Mountains, is called Christman's Valley. The Stone Mountain, the N.W. boundary of the main valley, terminates N.E. in a synclinal spur or ridge, which lies exactly in a line with Stewart's Knob, opposite to which it ends in Baird's Knob, about 3 miles to the S.W. of the former. Between the Seven Mountains on the N.W., and these two knobs or spurs on the S.E., lies Christman's Valley, leading both N.E. and S.W.; it is connected only laterally with the main portion of Kishacoquillas Valley.

FLEXURES OF THE STRATA.

Anticlinal Axis, Swartzel's Valley.—The anticlinal which elevates the limestone of the Kishacoquillas Valley, in a narrow belt along Swartzel's Valley, between Jack's Mountain on the S. and the mountain of Beattie's Knob on the N., issues E. through the united ends of those two mountains in Moser's Valley, opposite Adamsburg, and dies out in the Cadent and Vergent rocks. The dip on its S. side, in Jack's Mountain, must be very steep at first, since opposite to Beattie's Knob the terrace of Levant grey sandstone is within 50 feet of being of equal height with the crest of Levant white sandstone, and not more than 100 yards distant from it. At Brown's Gap, however, further to the W., the dip is 60° S., and the terrace is at its proper elevation of about two-thirds of the height of the mountain.

Anticlinal Axis of Orr's Valley.—The anticlinal of Orr's Valley, declining more gently E., keeps the mountain-walls asunder for 20 miles, and, when they finally unite to form Jack's Mountain at its E. end, issues upon the open country through Longstown Ridge at New Berlin.

Baird's and Stewart's Knobs.—The aspect of Baird's and Stewart's knobs from the higher hills in Kishacoquillas Valley is very striking, as they resemble the stern of a ship turned bottom up, the long and level keel rising high above the hull. Beattie's Knob projects further into the valley than Stewart's, and is more symmetrical, because the N. dips of the latter, being nearly vertical, have less successfully resisted denudation. The Levant white sandstone walls of Orr's Valley, E. of the point where its Levant grey sandstone terraces unite, are breached in no less than eight places into deep notches, by which the waters of that part are drained off to the E. without descending Kishacoquillas Valley to the Juniata. This feature, characteristic of this whole group of mountains, occurs on a small scale in the head of Swartzel's Valley, where a single breach in the S. crest drains the small surface back of the terrace. Three main streams descend the secondary valleys of Kishacoquillas Valley westward, repeatedly sink and rise again in the limestone strata, and, uniting below Sterrett's Mill, sink together at a place half a mile E. of Alexander's Cave, where the water reappears, and, flowing 3 miles further, passes through Brown's Gap in Jack's Mountain, and joins the Juniata at Lewistown. A small stream descends from the Seven Mountains, sinks below Perryville, and finds its way underground towards the gap. Another small stream descends through a breach in Baird's Knob, called Cooper's Gap, sinks at the border of the limestone, and, rising again at H. Taylor's, forms, with a larger spring opposite the Stone Church, the middle branch of the Kishacoquillas Creek.

The central part of the limestone area of the valley is traversed by several parallel but not equally elongated flexures. The anticlinal of Swartzel's Valley displays at Aiken's Sawmill a dip of 20° each way ; but where next seen, 100 yards S. of Swartzel's house, it is 400 yards nearer to the mountain ; at Sterrett's Sawmill, one mile further on, it lifts the Upper or Matinal fossiliferous limestones to the surface ; and 2 miles further W., at Kampel's house, the N. dip is 40°, declining rapidly from the axis N. to horizontality, then dipping 5° S., then 15° N., and again 10° S., and, lastly, gently rolling toward Perryville. At this meridian, the anticlinal of Swartzel's Valley, and the synclinal of Beattie's Knob, cease to be distinct single flexures, and terminate in gentle undulations. The exposures show pure blue limestone overlying the dolomitic layers of the formation. At Alexander's Cave, a somewhat magnesian limestone dips 10° S. 45° E., the dip increasing along the fine exposure down the creek to 45° S. 45° E., near M^cFarland's Mill, in fossiliferous layers, succeeded by good blue limestone, and this again by a thick mass of magnesian strata dipping 35°, 20°, and finally 10° S.E. Along the turnpike the prevailing dip is S., with a few small undulations. Here 600 feet of the dolomite layers, in absolute thickness, dipping 40° S.E., are opened in a quarry. The rock is sometimes grey, but generally milk-white, and finely granular. Lower and purer limestones issue from beneath it, with dips 15° and 10° S.E., as we pass towards the middle of the valley.

Anticlinal Axes of Perryville.—Two anticlinal axes issue from the mouth of Orr's Valley, and run past Perryville, one a quarter of a mile to the S. of the village, the other between it and the Furnace, and very near the latter. They are difficult to trace, because the strata are not only steep, but overtilted. At the Furnace, dark argillaceous limestones, belonging to the upper fossiliferous member of the formation, dip 55° S.E., and this I hold to be the overthrown N. side of the flexure; the corresponding slope of the other flexure being seen a quarter of a mile S. of the village on the turnpike, and again on the road to M^cNitt's, due E. of the village, dipping 50° N. 42° W. About 30 yards S. of the latter exposure is one of cherty dolomite dipping 70° S.E., and 60 yards

SPURS OF JACK'S M^T. EAST END OF KISHACOQUILLAS VALLEY.

further S., 50° S. 60° E.; then gentle undulations occur, setting into a steady S. dip extending to the undulations before described with the flexure of Swartzel's Valley. N. of the exposure, on the road to Wm. McNitt's, the N. dip declines from 50° to 20°, becomes 30° S., and then, in 50 yards, suddenly 72° S. 28° E., representing the more Northern and folded flexure. An overthrown dip of 55° S.E., near the margin of the slate, occurs upon a cross-road half a mile E. of Perryville; and at Laurence McNitt's house, 2 miles from the village, the folded anticlinal is again observed in the fossiliferous layers. Near this spot the more S. of the two flexures seems to die out Eastward. The axis of the other, still folded, passes on through a large sink-hole at McDole's, the two S.E. dips being 25° and 70°; and one mile further E., they stand 30° S.E. and vertical; and the axis passes on close by Stewart's Knob, making it of unsymmetrical form; beyond this the flexure unfolds, and continues regular and gentle. At Aiken's Sawmill the dips are 10°, the valley three-fourths of a mile wide, and the limestone, consisting of the uppermost strata, above the dolomitic member. The flexure is beautifully exposed in the last large sink-hole in the valley, 100 yards from Hugh Atkins' house, where the rocks are seen to dip 15° N. and 30° S. Between Baumgartner's and Close's the fossiliferous layers pass under the slates, and the limestone terminates.

Westward from Perryville, the folded flexure runs to the N. of Dr Henderson's house, and dies out somewhere to the N.E. of Belleville. The one next S. of it ends also N.E. of Belleville, and passes through Davis' Ore Bank.

A short flexure, with very gentle dips, runs parallel with the latter for 2 or 3 miles near its Western end.

Anticlinal Axis of Jack's Mountain.—Another flexure, which may be considered as the interrupted prolongation of the Swartzel's Valley anticlinal, originates about 3 miles W.S.W. of Brown's Gap, runs parallel with Jack's Mountain, and, about one mile from its foot, through the ore-banks S. of Belleville, and, half-way between Horrelstown and the mountain, approaches Stone Mountain, and then, curving to conform with the axis of the valley, continues S.W. as the anticlinal of Jack's Mountain. In its earlier course its rocks dip from 15° to 30°; but after the sudden change in its direction, the N. dip becomes and continues vertical.

Fault in Stone Mountain.—Here occurs the N.E. and S.W. line of fault through the Stone Mountain, by which the Levant white sandstone on the E. abuts against the Levant grey sandstone on the W.; while the terrace of the Levant grey sandstone, coming from the E., declines in a long point to McCullock's Fulling-mill. The fault is between 3 and 4 miles long, with a downthrow to the N.W. of perhaps 1000 feet. A very wide terrace, deeply gashed, is attached to the mountain W. of the fault—because of the gentle dip; but it narrows as the dip steepens, and almost ceases to be visible when, at the S.W. end of the valley, the rocks become vertical. The gentleness of the N.W. dip, for a few miles S.W. of the fault, spreads out the border of slate into the valley for a breadth of three-fourths of a mile from the foot of the mountain. The slate formation upon the N. side of Jack's Mountain dips with great regularity from 40° to 50° S.E., and unites with the other, over the anticlinal, within one mile of the S.W. end of the valley. This formation, after disappearing, in its turn, under the arch of Levant sandstone, where the mountains come together, is again exposed in the deep notch through which the Juniata River flows. This is the last appearance of Matinal rocks upon this great line of anticlinal flexure.

Jack's Mountain, with its terrace, is of remarkably regular form and structure, gently curving

Southward, with a change of 30° in bearing, from Brown's Gap to the Juniata. Its terrace is about 300 yards wide, and trenched into ravines at regular distances of from a fourth to a third of a mile, the drainage-waters of which usually disappear in a range of sink-holes at the margin of the limestone. These sink-holes differ in no respect from those by which the range of the folded anticlinal axis of Perryville is marked.

The anticlinal of Kishacoquillas Valley lifts the Levant sandstone formations in a mountain-range for miles beyond the termination of the valley. This mountain has a straight crest; it measures 2 miles in width at its base, and contains rocks dipping 25° S.E. on its S. side, and is nearly vertical on the N. It has for the most part two distinct summits; but 6 miles S.W. of Drake's Narrows, where the Juniata crosses it, there is a third summit, and probably another short anticlinal flexure. Silver Mine Hill, the middle summit, is a mass of white sandstone, dipping 60° S.E., and between it and the N.W. summit runs the great anticlinal of the mountain, over which these two summits soon unite in Standerfer's Knob, which overlooks the whole region. For 2 miles S.W. of Standerfer's Knob the mountain is low and flat, with a red soil under cultivation; it rises and finally slopes away to a point in the plain at the "Three Springs."

ROCKS OF KISHACOQUILLAS VALLEY.

The Auroral Limestone of Kishacoquillas Valley occupies the following limits: Its S. border runs within 500 yards of the foot of Jack's Mountain, and 100 yards S.E. of Brown's Mills. Its N. margin runs between Thompson's Tavern and the Furnace. To the E. it runs along Jack's Mountain only to a short distance beyond Sterrett's Mills, where the upper fossiliferous layers are seen, for one mile E. of this, at Swartzel's, the slate formation already fills the narrow valley. The limestone ascends Orr's Valley to within one mile of Close's. In Christman's Valley only its uppermost layers rise along the central line—well exposed on Christman's farm—but cut off entirely from the limestone of the Kishacoquillas Valley by a broad synclinal belt of slate, that unites the bases of Baird's and Stewart's knobs.

In the meridian of Brown's Gap the limestone occupies the valley in a breadth of about 3 miles, narrowing W. with the valley, so that at Horrelstown it is but 1½ miles wide, and it disappears from the surface 7 miles further W.

The Matinal Limestone (Trenton limestone) is in some force in Kishacoquillas Valley, and in all the valleys of Centre County; but the Matinal black slate (black Utica slate) is more imperfectly developed.

The Matinal Shale formation encircles the limestone area just described, encroaching upon it at one place N. of Belleville because of the dislocation. The upper limit of the slate or shale is usually at half the height of the terrace or inner ridge of the mountains, and its lower margin extends a few hundred yards into the valley. The upper portions of the formation are exposed, in Brown's Gap, in the form of an olive, fine-grained, laminated slate, blackening and crumbling to the weather, with a few layers of steel-grey striped thin sandstone, and layers of silicious ferruginous limestone, full of species of fossils similar to those observed in the same formation in Nippenose Valley. These sandstones, separated by shale, increase in number upward.

IRON ORES, ETC. OF KISHACOQUILLAS VALLEY.

Surface Ores.—These ores possess the usual characters of those of the other similar limestone valleys. Imbedded in accumulations of clay and loam, and generally having no very close relation to the rocks beneath, their discovery is rather empirical. In Kishacoquillas Valley, however, we find an exception to this statement, for there the distribution of the ore is so dependent on the geological structure that its range can be determined with scientific accuracy. All the ore-deposits hitherto mined lie over the anticlinal lines of the strata, in the fissures produced by their abrupt bending at the time of their original elevation. And it is probable that no large amount of ore will be found anywhere else in the valley. The anticlinal axes in this valley are four in number. In the principal one the rocks are overturned on the N.W. side for the greater part of its course. It ranges near the foot of Stone Mountain, and parallel to it.

Two shorter axes lie S.E. of its S.W. extremity, on the more North-western of which is situated Davis' Ore Bank. The fourth axis, commencing about 3 miles S.W. of Brown's Gap, becomes the main axis of the W. end of the valley, and on this occurs the principal deposit of ore of this neighbourhood.

Davis' Bank.—This bank was exhausted at the date of the survey. It consisted of a mass of the variety called pipe ore. The pipes or stalactitic stems were arranged perpendicularly with singular regularity. About 800 tons of this variety were dug and smelted in the Greenwood Furnace. Whether any ore exists at other points along this line is not known, but a close inspection of the condition of the strata immediately at the change of dip, or along the anticlinal axis, would probably result in the discovery of other deposits.

Holliday's Ore Bank.—This deposit was not worked when examined by us. It is near Holliday's Mill, E. of Greenwood, and is situated exactly on the main anticlinal axis. In the excavation the limestone rock on both sides is visible, and can be seen dipping in opposite directions. The ore has the usual characters. Fluor-spar occurs here in small quantities.

Old Ore Bank of Hall and Rawle.—This is situated exactly on the axis, about one mile S.E. of Greenwood. It had been worked for many years. It was a large open excavation, 70 feet deep. The ore in some places was almost unmixed with clay. At the depth of 70 feet a bed of ore was reached, of great thickness. The ore of this deposit was both stalactitic in form and in irregular masses, presenting often mamillary projections on one side.

Brookland Furnace Ore Bank.—Several excavations were made by the proprietors of Brookland Furnace—one near Hall and Rawle's, and another nearly one mile S.W. The latter lies exactly on the anticlinal axis. The prevailing variety is that called pipe ore.

Beside these deposits, it is probable that others, equally productive, might be developed in the Kishacoquillas Valley, by tracing each line of axis, and observing where a fissure seems to exist immediately at the turn of the dip.

McConnellsburg Cove.—There are no large deposits of iron ore on the limestone of the McConnellsburg Cove, but in some places ore lies scattered on the surface. On the Patterson Farm, 3 miles S.W. of McConnellsburg, ore thus exists on the Auroral limestone, but impurities render it unfit for use. On a farm half a mile N. of the preceding, a brown argillaceous iron-ore was found, and it was used at Hanover Furnace, but it yielded a metal of an inferior quality.

Hanover Ore Bank.—The only ore found in this district on the Matinal slate is that formerly used at Hanover Furnace in Fulton County. It is situated on the S.E. flank of Lowrey's Knob, where the Matinal slate emerges from the fault. The slate is in great disorder, and even crushed into a mass of mere clay, where the ore occurs. A thin waving stratum was first found, which, when traced, took a perpendicular descent, and became much thicker. This ore lies between two walls of clay, that on the lower side being unctuous and beautifully coloured. It consists of several varieties, the greater portion occurring in angular masses of considerable size, and having a cleavage similar to that of the adjoining clays. It is compact and ponderous, and of a dark reddish brown colour, but not of uniform tint or richness. Another variety is black, crumbling, and less ponderous.

These ores, as originally smelted with the cold-blast, made good malleable iron, tending rather to the red-short character.

The clays on the lower side of the ore-bed are different from those above, and appear to be more impermeable to to water. They may have operated as a floor for the oxide of iron while it was accumulating. A section of Lowrey's Knob and the ore has been given. The relative thickness of the ore is much greater in the drawing than in nature.

Ice Cave.—The most remarkable of all the sink-holes in the valley is the so-called Ice Cave, one mile from Perryville, and 300 yards from the road. A natural well, 25 feet deep, with steep walls nearly rectangular, exhibits in its E. side the entrance to a cold dark cavern adorned with stalactites pendent from the roof, and stalagmitic concretions on the floor. Rudely-fluted columns rise around the sides. There is an apparent dip in the strata of 10° or 15° to the S.E., but numerous fractures express the extensive settling of the whole mass into the vacuity of the cave.

Four grinders of a Mastodon (one 16 inches in circumference), and part of the skull of the same extinct animal, it is said, were found 3 miles S.W. of Brown's Mill, resting upon rounded pebbles, and covered with a few feet of alluvium.

Matinal Black Slate, erroneously dug for Coal.—At Copeland's Mill, the lower beds of the slate are so black as to have seduced proprietors of land into an unavailing search for coal. It is the Matinal black slate, and of course cannot indicate coal.

Sinking Spring Gap.—The actual drainage of the Kishacoquillas Valley is doubtless a good guide for us in detecting the course of the ancient excavating waters. Large masses of fragmentary sandstone from Sinking Spring Gap lie strewn to the S.E. for a mile into the valley, in connection with a great mound of sand-drift. The fragments in the gap near Allenville took the same direction for an equal distance. Debris and sand cover the surface at the Northern edge of the valley, the whole length of Stone Mountain, but in a less degree along the foot of Jack's Mountain.

Christman's Valley.—This is the most Northern division of Kishacoquillas Valley lying behind Stewart's and Baird's knobs, and of the base-line of Matinal slates which unite them, from the top of which the synclinal mass of Levant sandstone has been swept away. The anticlinal axis of this valley, rising a little N. of Mifflinsburg, ranges along the crest of White Mountain, and W. through the ridge that looks down into Stone Valley, upon Greenwood Furnace, or into the Warrior Ridge. A small part only of this valley is occupied by the uppermost beds of the limestone formation. A dislocation that traverses the Seven Mountains contorts the Matinal slates on the creek N. of Thompson's Tavern, where they are seen overthrown, dipping 75° towards the S.

CHAPTER IV.

REGION OF THE SEVEN MOUNTAINS.

Several parallel ridges of the outcropping Levant white and grey sandstone formations, forming together an elevated table-land of complicated topographical structure, separate the limestone valley of the Kishacoquillas on the S.E. from the limestone valley of Pine Creek on the N.W. It is the shallowest portion of that great geological basin which deepens Eastward through Buffalo Valley, and finally, far to the E., receives the Wyoming coal-basin. Westward it deepens still more rapidly through Stone Valley, until it holds the coal-measures of the Broad Top Basin. Where the Lewistown and Bellefonte turnpike crosses these ridges they number seven. The relations they bear to each other, and to the two chief anticlinal flexures that longitudinally traverse the general basin here, will be apparent from the following section made along the road.

Four of the depressions or valleys between these ridges are there seen to contain rocks of the Levant red sandstone formation. A broad and gentle anticlinal flexure brings up Matinal slates between the fifth and sixth ridges, while the Surgent slate and shale groups lie synclinally

Fig. 85.—Section across the Seven Mountains by the Turnpike Road.

between the second and third. Here, then, close by the S. margin of the district, runs the deepest line or true synclinal axis of the whole geological basin, considered as one, the rocks on the S. side of this central line—that is, those composing the mountain overlooking Christman's Valley and the one next N. of it—being not only steeply inclined, but overthrown. This same feature will hereafter be found prominent in the basin, when we come to examine it in the valley, and further towards the S.W. In traversing the mountains near the line of our section, the turnpike winds round the end of the third mountain, keeping upon the red sandstone formation.

Traced E. from the turnpike, the First Mountain is the terrace that encircles and fills the upper portion of Christman's Valley. The Second and Third mountains include a deep, narrow, folded, synclinal valley of higher Surgent slates and shales, and other soft rocks, which, by the shallowing and unfolding of the synclinal trough, come gently to a head, the two mountains forming but one, which is broad and level on its surface, and still of synclinal structure, as may be seen in the following section.

Fig. 86.—Section across the Seven Mountains, 5 miles E. of the Turnpike.

The synclinal of this broad mountain-top deepens again, however, as we continue E., and two mountains, almost imperceptibly diverging E., result as before, the one on the S. forming the N. side of Christman's Valley, and uniting with the prolonged ridge of the Stewart's Knob Mountain, and ending in White Mountain; the other running forward as the N. barrier of the upper end of Buffalo Valley, and called Paddy's Mountain. This mountain exhibits at its extremity the anticlinal of Po Valley, and returns S.W. as Big Mountain, afterwards to be described. A section from Hartman's in Buffalo Valley, N. to a point 3 miles to the E. of Aaronsburg, exhibits this new separation of the second and third ridges, and also the recurrence of the latter in Big Mountain.

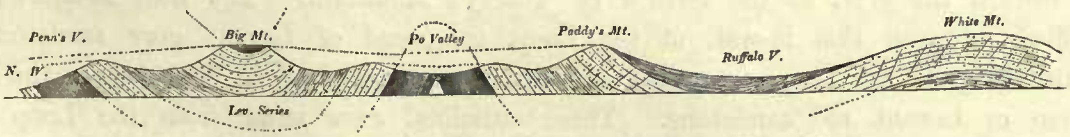


Fig. 87.—Section across the Seven Mountains, from Hartman's northward.

The small anticlinal between the Third and Fourth mountains may possibly expire in the general high land into which the Third Mountain flattens out at the head of Po Valley; or, more probably, it suddenly increases in size, and becomes the anticlinal of that valley, passing out from its head through the end of Paddy's Mountain. On this latter supposition, the anticlinal between the Fifth and Sixth mountains gradually declines and disappears by the side of the other, and on the N. side of the Po Valley, long before reaching the meridian of the end of Big Mountain. The synclinal valley between the Sixth and Seventh mountains continues for 14 miles with great regularity, deepening to the E., and then receives upon its included formation of Levant red sandstone the synclinal mass of Levant white sandstone that forms the Big Mountain. This, traced E., is parted into two mountains by one of the Surgent slate and shale valleys that run up from Buffalo Valley, the Southern mountain helping to form Paddy's Mountain, while the Northern—through which are the Seven-Mile Narrows—goes to form Brush Mountain : this omits the anticlinal of Penn's Valley, and returns to form the adjacent mountain.

From the summit of Big Mountain the contours of the ridges to the S. of it are very striking, marking the direction and intensity of the denuding waters.

The rocks of the First and Second mountains are overthrown, and dip S. at the turnpike line of section. When traced W., they are seen to be broken by a transverse North-and-South-running fault, on the E. side of which the strata dip 50° to the S.E., being folded under backward, by pressing against the more upright edges of their equivalents composing the W. wall of the fault. Beyond the fault the two mountains unite with Baird's Knob Terrace and Stone Mountain in a bold anticlinal, projected into Stone Valley, and called Broad Mountain. The Third and Fourth mountains unite W. in a similar anticlinal knob and spur, projected into the extreme head of Stone Mountain. They are unaffected by the fault. The Fifth and Sixth mountains also unite, and thus head in the anticlinal valley of Matinal slates seen in the turnpike section. Outside of their union the N. arm of the Fourth Mountain—which, being synclinal, separates W. into two—unites with the S. arm of a similar synclinal mountain, which, originating between the Sixth and Seventh mountains a few miles W. of the turnpike, separates W. in like manner into two. The N. one of these becomes Bear Meadows, and afterwards Tussey's Mountain, and the S. unites, as was just said, with the Northern of the Fourth Mountain, in a third spur projected into Stone Valley.

Anticlinal Spurs and Axes.—This united anticlinal end of two outcrops of the Levant white sandstone formation, is greatly obscured, however, by unusual denudation. A glance at the Map will show that the synclinal mountain of the Levant white sandstone, here alluded to as originating W. of the turnpike, between the Sixth and Seventh mountains of the sections, corresponds to Big Mountain. In fact, 20 miles of Levant white sandstone have been swept away from between their opposed ends. The Seventh Mountain, when traced W., forms the inside of the Loop, sweeps round its outside end, and continues toward the S.W. as the terrace of Tussey's Mountain. The Bear Meadows lie in the hollow between this in-wall of the Loop, composed of Levant grey sandstone, and the main sweep of the Loop, composed of Levant white sandstone. They cover the middle formation or Levant red sandstone. Three anticlinal axes issue from the Loop Mountain S.W., and form three spurs or fingers projecting into Stone Valley. These three anticlinal flexures seem to be the resolution of the single great anticlinal which traverses the Loop and George's Valley, and cuts off the synclinal fragment of Levant grey sandstone and Matinal slates, known as Egg Hill, from the main body of the Levant sandstone formation in the Seven Mountains.

Seven Mountains.—The Seven Mountains and Tussey's Mountain, as their continuation toward the S.W., form the S. barrier of the great anticlinal Auroral and Matinal region hereafter to be described, of which the Bald Eagle Mountain is the N. barrier, and which, subdividing E. into George's, Penn's Creek, Brush and Nittany valleys, is headed up in that direction, and walled in from the great plain of the Susquehanna River by the complicated foldings of the Levant sandstones known as the Buffalo Mountains. These may be considered as the N.E. prolongation of the Seven Mountains, which they serve to connect with the Bald Eagle range. They deserve, therefore, our next share of attention, and will be described in the usual order from the S. towards the N.

CHAPTER V.

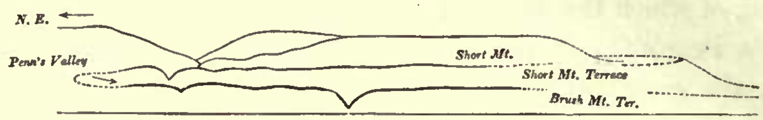
REGION OF THE BUFFALO, NITTANY, AND BALD EAGLE MOUNTAINS.

In describing Buffalo Valley it was found necessary to mention in due order the anticlinal knobs or spurs that descend into it, one beyond the other, from the mountain region on the W., as well as the long narrow pointed synclinal vales or large ravines which head up between them. These vales descend between mountains composed of the Levant white sandstone formation. Through breaches in these ridges flow rivulets which drain an elevated plateau, which in each case lies back of the ridge, and forms an inside terrace of Levant red sandstone, the inner edge of which is made by the outcrops of the Levant grey sandstone, and looks down upon included sharp and narrow anticlinal valleys of Auroral limestone widening to the W., and at length sweeping round the blunt synclinal ends of the long terraces. A glance at the Map, better than any description, will show the exact concordance between the structure of the mountains here, and those which project into Kishacoquillas Valley, known as Beattie's and Stewart's knobs. The same resemblance to the keel of an upturned boat marks the long ridges of white sandstone upon the Short, the Brush, and the Nittany mountain terraces, and constitutes an analogy between these and the Big Mountain, described in the last chapter as belonging to the region of the Seven Mountains.

Short Mountain is a synclinal triple ridge that rises from the floor of Penn's Valley, 5 miles E. of Aaronsburg. It has the long anticlinal vale of Penn's Creek Narrows on the S. between it and the Seven Mountains, and the narrow Penn's Valley-head on the N., between it and Brush Mountain. Its N. terrace, and the parting of its central ridge or keel Eastwardly, notched deeply by denudation, as seen from Brush Mountain summit, is given in the following sketch. (See Fig. 88.) The terrace of Brush Mountain occupies the foreground.

Brush Mountain is similar to Short Mountain in structure and appearance, being a long straight synclinal ridge of Levant white sandstone, supported by Matinal slates. It separates Penn's Valley from Brush Valley. While the end of the uppermost ridge or keel is opposite Aaronsburg, the terrace runs on—broken only by Elk Creek at Millheim—in a double line of high and rugged hills, as far S.W. as opposite the E. end of Egg Hill, and between the two lies a high and narrow vale of Levant red sandstone rocks. Two miles from its S.W. end, the

FIG. 88.—Short Mountain and Terrace, seen in profile.



Terrace Mountain is traversed by a cross ravine, at which its division into two mountains seems to commence. E. of Elk Creek Narrows, the central mountain is not affected by the gorges that cut the lateral terrace-ridges. The N. terrace-ridge attains, 6 miles from Rebersburg, such an altitude as to hide the central keel behind it. The union of the S. terrace-ridge of Brush Mountain with the N. terrace-ridge of Short Mountain, at the head of Pine Creek Narrows, forms a high knob. The N. ridge of Brush Mountain effects a similar junction with the S. terrace of South Nittany Mountain, and closes up Brush Valley Narrows. The central mountain now parts into two, 5 miles E. of Peterman's. The N. member, known as the Notch Mountain, sweeps on along one part of the N. line of Buffalo Valley, and forms, with the next complementary ridge to the N., the long declining spur, by which the expiring anticlinal of Brush Valley issues and runs on towards New Columbia on the Susquehanna River. Where it parts from the S. member—which runs on to form a similar anticlinal spur by uniting with the Path Valley Mountain—it is the lower of the two, and is hidden from view behind the high terrace-ridge to the N. of it. It is remarkable among all the monoclinal ridges, from the number of breaches effected through its crest. In the following sketch made from the summit on the N. side of Brush Valley, 7 miles E. of Peterman's, the parting and relative heights of the central ridge and N. terrace are shown.

FIG. 89.—Sketch of Brush Mountain, from the N. side of Brush Valley.

Plateau of Nittany Mountain.—Between Brush Valley and Sugar Valley—which differs from Brush Valley only in this particular, that it is headed up at both ends by a junction of its anticlinal walls—runs a double range of mountains, composed of the Levant grey sandstone formation, supported on Matinal slates, the high trough between being filled with red sandstone rocks. This double range of mountains, where traced W., becomes, as to its S. member or North-dipping outcrop, the terrace of the Nittany Mountain—as the Map will show—terminating opposite Boalsburg. Its N. member encircles Sugar Valley in terrace form. It is, of course, of synclinal structure, flexed between the continuous anticlinal of Brush Valley on the S., and the anticlinal, expiring W., of Sugar Valley on the N. Had the anticlinal of Sugar Valley maintained itself W., like that of Brush Valley, and thereby opened Sugar Valley out W. into Nittany Valley, as Brush Valley opens W. into Penn's Valley, this synclinal terrace—or double range of mountains separating Brush and Sugar valleys—would have run on W. without material alteration of form, and simply terminated at some point in the great limestone region, determined by the amount of the resistance its line afforded to the universal denudation—as the Brush Mountain does near Good Spring. But by the anticlinal of Sugar Valley expiring W., this synclinal range widens and deepens for a space in this direction, and it thereby retains a remnant of upper Levant white sandstone rocks in the normal form of a third, central, higher keel-like ridge, the true Nittany Mountain. This central synclinal ridge, rising opposite Rebersburg, soon ceases; and while the Southern (North-dipping) crest keeps its S.W. course, broken by gaps, just behind the terrace of Brush Valley, the N. member curves round the end of Sugar Valley—back of its terrace—runs along its N. border North-eastward as a North-dipping monoclinal ridge, as far as one-half of the length of Sugar Valley. Behind its terrace it sharply recurves, and returns along the S. side of Nittany Valley—back of its terrace—and finally, in unison with the W. end of the S. member, terminates in a synclinal central ridge or keel at the Lewistown and Bellefonte turnpike.

Pheasant Valley.—The space enclosed by this inner mountain of Levant white sandstone, is, with the exception of a few gaps, a continuous elevated valley of Surgent shales and slates, called Pheasant Valley. It is drained by streams flowing through its N. barrier into Fishing Creek. Big Fishing Creek, which flows through the whole length of Sugar Valley, makes a deep traverse of the N. synclinal portions of this Pheasant Valley, breaching its two outer terraces and its two inner crests.

The simple synclinal double barrier between Brush and Sugar valleys, when traced E., receives, by the insertion of a short anticlinal axis from the E., a complex topographical character. Considered as a terrace, it divides itself into two, upon each one of which rises a central ridge or keel of Levant white sandstone. Considered as a double synclinal range of mountains, it becomes two triple synclinal ranges of mountain. The anticlinal which thus parts it forms a small, narrow, and short slate valley, with a line of limestone above its bed.

Like Sugar Valley, had its anticlinal been continued W., it would have opened this little vale out into Sugar Valley. As it is, that result has almost been attained. The anticlinal of this little valley expires so closely at the S. edge of Sugar Valley, that the barrier-terrace is almost sundered from the synclinal between Brush and Sugar valleys.

The central keels of both synclinal sets of mountain—one between the Little Valley and Sugar Valley to the S.—terminate in bold knobs on the same meridian, and near the W. end or foot of the Little Valley.

These two central synclinal crests or keels separate, as we have seen; Big Mountain, Short Mountain, and Brush Mountain recede, and from their elevated summits descend into the plain of the Susquehanna two additional Surgent slate and shale ravines or branch valleys widening into Buffalo Valley. The S. one goes out between the declining spur that contains the Brush Valley anticlinal called locally the Buffalo Mountain, and that which has the anticlinal of the Little Valley just described, called locally Nittany Mountain. The N. one is the valley of Whitedeer Creek, having the anticlinal (local) Nittany Mountain on the S., and the anticlinal Whitedeer Mountain on the N.

Mountain Spurs of Union County.—This obliquely-arranged series of mountain-crests, which shuts in Buffalo Valley and its branches upon the W., may be continuously traced as follows:—The ridges Nos. 2 and 3 of the Seven Mountains, running out into Buffalo Valley as Paddy's

Mountain, recurve as the Big Mountain. This projects E., and returns W. as Short Mountain, which in turn points E., and returns W. as Brush Mountain. This again runs to the E. as Buffalo Mountain, and returns W. as the keel or crest to the S. of the Little Valley, which crest extends E. again as Nittany Mountain (locally so called), and returns W. as the central crest and knob on the N. side of the little valley between it and Sugar Valley. This again stretches E. as Whitedeer Mountain, and, making an anticlinal point at the Susquehanna opposite and above Watsonburg, returns Westward to encircle the broad synclinal valley of the Whitedeer Hole, whence it bends North-eastward again as Whitedeer Hole Mountain, and, making the last anticlinal point of the series opposite Muncy, sweeps broadly and finally away as the Bald Eagle Mountain, ranging far to the S.W.

In tracing these large features of the region, it remains to add, that while this curiously-winding mountain-crest owes its existence to the regular parallelism and uniform E. declination of the anticlinal axes Westward, the softer Levant red, and the harder Levant grey sandstones, produce the remarkable terraces overlooking the anticlinal valley. These terraces become more and more prominent as a topographical feature as we go N., because of the increasing breadth and decreasing steepness of the anticlinal flexures in that direction. Where the dip approximates to the perpendicular, the grey sandstone occupies the place of a subordinate bench upon the main mountain of the white sandstone. This is the case in Kishacoquillas Valley. Where the dip, still steep, is not excessive, the bench is a well-defined terrace or platform as in the Seven Mountains, and at the end of Brush and Nittany mountains, and in the barrier between Brush and Sugar valleys, also in the E. heads of Penn's Creek and Brush valleys. But where the dip approximates to horizontal, the whole country is covered with a mountain upland by the spreading and coalescing of the terraces of the Levant grey sandstone, the upper or white sandstone alone appearing in the crests around its N., S., and E. borders. Out of this mountain region has been scooped, in a broad curve, the E. head of the great Nittany anticlinal limestone valley, and out of its interior have been excavated, by the same denuding actions on the summit of the anticlinal wave, the grand deep oval craters of Nippenose and Musquito valleys.

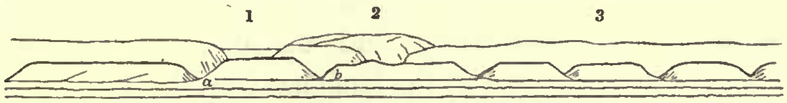
Little Valley.—The little anticlinal so often mentioned as lying between the end of Sugar Valley and the head of Brush Valley, discloses, near Grove's Licks, a body of calcareous Matinal slates, and would, if stripped of its timber, afford many acres of arable soil.

Nittany Mountain.—What remains to be noticed of the mountain region embracing Pheasant and Sugar valleys will be introduced under this head, because the name of the synclinal keel-shaped central ridge opposite Bellefonte not only extends to the great valley to the N.W., but it attaches equally to the quite distinct range along the N. side of Brush Valley. In fact, all the mountain-land between Brush and Nittany valleys may be called the Nittany Mountain, and shut within it are both the Pheasant and the Sugar valleys.

The synclinal termination of the Levant grey sandstone terrace to the S.W. is near Centre Furnace, 8 miles S. of Bellefonte. Traced E., it soon becomes two ridges, with an elevated red sandstone vale between them. A gap in the S. ridge marks the point where the separation begins. At the turnpike road they are about one mile asunder. Here they receive between them the central ridge or keel of Levant grey sandstone rocks, which rises to twice their height, and they form its two opposite terraces. The following is an outline sketch of the Nittany Mountain and its N. terrace, as seen from the Bald Eagle Mountain.

About 4 miles E. of the turnpike, the central Nittany Mountain divides to enclose Pheasant or "Little Sugar" Valley; and 6 miles E. of this point the S. branch makes an angle with the E. convex wall of Pheasant Valley, and runs on a little further E. until swept away,

Fig. 90.—Nittany Mountain and Terrace, as seen from Bald Eagle Mountain.



1, Fishing Creek Gap. 2, Drain Gap of Pheasant Valley; 3, behind it is seen the high knob that closes the South-western end of Sugar Valley. Northern barrier of Pheasant Valley, becoming, S.E., Nittany synclinal keel. *a* Washiogton Gap; *b* Johnson'e Gap—both in the terrace-ridge.

opposite Rebersburg. The head or S.W. end of Pheasant Valley is notched in a broad gap—Cook's Gap—which is through the terrace-shaped ridge below it. The dip of the rocks in this N. wall of Brush Valley is everywhere very steep; at the turnpike, 60° N. 35° W.; the same at Cook's Gap; and at 10 miles E. of this it is 45°. The South-dipping strata in the E. angle of Pheasant Valley are much more gentle in their inclination, and this is due to the expiring of the Sugar Valley anticlinal.

Big Mountain.—The N.W. barrier of Pheasant Valley (locally called the "Big Mountain"), is cut down to its base at Johnson's Gap, and 1 or 2 miles further N.E. at Washington Gap. In Johnson's Gap, the Levant grey sandstone, forming the terrace-ridge outside, dips 35° S. 45° E., and the white sandstone of the Big Mountain about the same. The North-west dip in the mountain opposite and to the S. is 45°, and 12 miles to the E. the two synclinally-opposed crests unite.

A curious knob, or short spur, may be seen projected from the Big Mountain just within and on the W. side of Johnson's Gap. It is probably the result of denudation upon a small local flexure.

Pheasant Valley is about 2 miles wide from summit to summit. At the widest part it has no strictly level land in it, is very stony, and for the most part heavily timbered.

The Big Mountain, from Washington Gap east, presents from a distance a summit-line of very remarkable elevation and regularity. The terrace of Levant grey sandstone forms a separate lower parallel and outer ridge, insulated from the main mountain by a divided though elevated vale in the red sandstone.

The road from Nittany Valley enters Sugar Valley within three-quarters of a mile of its W. end, by a long-winding notch or pass through the two terrace-ridges, and the two inner higher ridges of the synclinal barrier between the valleys. This double gap opens Northward at Washington Furnace. As the anticlinal axis of Sugar Valley ranges within 300 yards of the foot of its N. terrace-ridge, the dip of the rocks in the latter is nearly perpendicular, and in the main or grey sandstone mountain—back of the terrace—the rocks are overturned so as to dip at 70° S.E. This presents a striking contrast with the state of things observed in Johnson's Gap, where the North-west-dipping rocks are inclined but 40°. No evidence of a transverse fracture, however, has been observed.

About 11 miles further to the E., or one mile W. of Kleckner's Gap, and where the two synclinal middle Levant white sandstone ridges loop into one, or where, as we may with propriety express it, the synclinal trough suffers a sudden shallowing E., and the terrace is swept for 8 miles clear of the superincumbent white sandstone strata, the grey sandstones of the terrace-ridge dip 47° N. 15° W. Behind it rises the knob of the white sandstone, formed by the united inner ridges in nearly horizontal stratification. From the summit the eye wanders over a great rolling plateau stretching to the N. and E., and composed of a nearly horizontal floor of Levant grey and red sandstone strata, within which lies, deeply sunken, the Nippenose or Oval Valley. The blunt termination of this superposed synclinal mountain is due to the interference of numerous subordinate anticlinal flexures traversing the plateau. It is narrow, and of very gentle slope. The synclinal flexure so flattens out and rises towards the N.E., that all the white sandstone has been here removed, while the S. shoulder of the knob has been so rounded off that only South-dipping strata remain. A diagram will explain this.

Fig. 91.—Section of Nittany Mountain, opposite the E. end of Nittany Valley.

A dip of 10° to the N.W. is observed on the road from Sugar Valley into Nittany Valley, in the hollow between the Big Mountain and the N. terrace-ridge. This argues the presence of another gentle undulation. The subordinate undulations, by spreading out the chert undulation, have produced the great width of the Nippenose, Nittany, and Muncy anticlinal, and the Deerhole Valley synclinal.

Anticlinal Belt between Nittany and Nippenose Valleys.—The normal inclination of the rocks through Nittany and Nippenose Valleys is anticlinal, but this anticlinal line is not geologically horizontal, nor even of one regular gentle curve, for if it were, no reason could be suggested for Nippenose not being continuous with Nittany Valley. The axis of flexure must undulate in a vertical plane. On the edge of the plateau which looks down upon Nittany Valley at its head, the dip is to the E., or along the axis. On the other side of the same plateau, the dip of the rocks at the S.W. end of Nippenose Valley is also along the axis, but in the opposite direction, and stronger, 15° to S. 60° W. The annexed diagram is intended to explain the phenomena, by

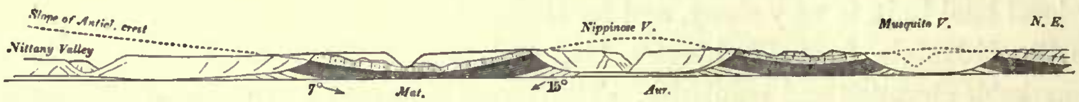


Fig. 92.—Section along the Anticlinal Axis through Nittany, Nippenose, and Musquito Valleys.

giving a section of the three valleys, with their intervening mountain table-lands, the long crest-line of the Bald Eagle Mountain with its outlet gaps bounding the view to the N.

The oval form of these valleys would have been more perfect, but for local deflections of the denuding currents to certain points. The top of the Matinal series has just reached the surface on McElhatten's Run.

Nittany Valley Anticlinal Axis.—The sinking and flattening down of the great Nittany or Muncy anticlinal towards the E., is well shown in the double ridge of the Bald Eagle Mountain, which is remarkably regular, and free from interfering flexures or offsets, while the numerous breaches in its wall reveal the finest sections. In the S.W. its strata exhibit a very steep inclination. From Birmington to Millhall the dip of the strata is often vertical, or even overturned. Of course, both the main N. ridge and its terrace have irregular summit-lines ; indeed, the latter is exceedingly broken. In Fleming's Gap the anticlinal has so flattened as to allow the dip of the terrace strata to be but 30°, and that of the main ridge about 45°. The latter, therefore, presents an appearance very different from its aspect further W. ; its crest is high and very even, and so it continues past Nippenose Valley. At the Loyalsock Gap, 3 miles below Williamsport,

Lehman

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LEHIGH WATER-GAP, FROM STONE RIDGE

the dip of the white sandstone is about 30°. Through this gap passes the main road to Whitedeer Valley, traversing an extensive rolling upland, which is intersected by numerous small streams. This table-land lies E. of the high knob formed by the union of the Levant grey sandstone walls of Musquito Valley, and is shut in on the N. and S. by the converging crests of Levant white sandstone forming Whitedeer and Bald Eagle mountains.

Gaps.—Three gaps enter Nippenose Valley from the N.: Love's Gap, the most Westerly, cuts only the terrace-ridge; Anti's Gap, through which the chief outward breaching currents must have poured; and a gap in the N.E. corner, similar to Love's Gap, also confined to the terrace. A few of the notches or slight depressions, in the crest of the terrace or inner ridge, have deeper gaps in the outer ridge to correspond with them. This is a reversal of the usual order, according to which the terrace is the more broken of the two.

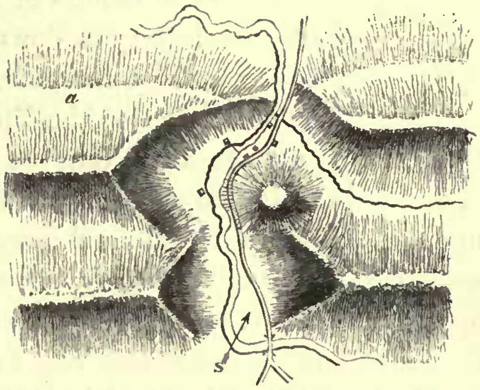


FIG. 93.—Drift Mound in Anti's Gap of Nippenose Valley.

The small circular mound or hill in the centre of Anti's gap, best seen when regarded from either of the four summits of the mountain, is a striking instance of an eddying or vortex-like action in the retiring drainage of the waters as they swept through the notches. (See the Diagram, fig. 93.)

A similarly-formed eddy hill, but of a different shape and size, is to be seen in the Washington Gap, leading from Nittany into Sugar valley.

In the water-gap of the Lehigh, seen from the N., a very regular broad mound is visible, which has evidently been formed by a whirling motion at the confluence of the great currents which here converged to pour through the breach in the Kittatinny Mountain.

On the contrary, the floods that swept *out* of the Nippenose Valley, and over the high land to the S. of it, ravined its S. wall at nine different points. The Westernmost has no name; the others are known as Shaw's, Soladay's, Pence's, Clark's, McMakin's, Cole's, Sotz's, and Rattling Run gaps; McMakin's is the most profound. Thus nearly one-half of the bulk of the S. barrier has been swept away, and its appearance, when it is viewed in profile, is peculiar, as shown in the sketch here given.

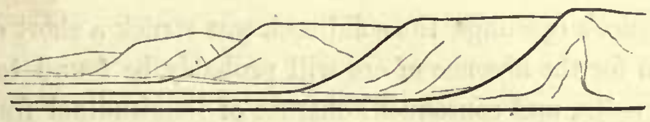


FIG. 94.—Perspective Sketch of the Ravines in the S. Barrier of Nippenose Valley.

In a section made from Nippenose S. to Sugar Valley, the most Southern of the two small anticlinals observed in the loop of the Big Mountain west of Kleckner's is crossed, but not the other one. To this, and perhaps to other small anticlinal undulations not discovered, we must ascribe the great breadth of the red sandstone terrace-country between the N. edge of Sugar Valley and the S. wall of Whitedeer Hole Valley.

CHAPTER VI.

NIPPENOSE, OR THE OVAL LIMESTONE VALLEY.

Nippenose Valley is about 11 miles in length, N. 78° E., and 3½ in breadth. Its floor of Auroral limestone extends in its middle region to the foot of the mountain-wall on each side; but towards its ends it occupies less space, because, by a necessary law of denuding action, when a great anticlinal flexure declines in a given direction, though it retains the same amount of wave curvature, yet being cut down to a higher relative level on the wave, the dips at the surface will be of gentler inclination, and consequently the whole outcrop of the upper strata broader. Thus at Anti's Gap the dip is 35° N., but at Love's Gap only 12° N. 30° W.; at Rattling Run Gap, 10° S. At Anti's Gap the limestone comes quite up to the mountain, into the very side of which the Matinal slates ascend two-thirds its height. But at Shaw's Gap the fossiliferous uppermost layers of the Matinal limestone occur 200 yards S. of Mr Shaw's house, dip 5° S., and no limestone can be found any nearer the mountain opposite Love's Gap. Limestone has been opened 2 miles W. of Shaw's, and within 1 mile of that end of the valley. At Rattling Run Gap, Mr Clark's house is very near the highest beds, which are therefore closer to the mountain at this than at the W. end of the valley.

Subterranean caves in the Auroral limestone strata must be numerous and extensive, for all the streams that descend from the mountains around sink beneath the surface at the lower margin of the slate, and reappear together in a deep-blue pool of water, surrounded by walls of the limestone which lies within half a mile of Anti's Gap, through which the whole united drainage of the valley escapes to the Susquehanna. This cave-born little river abounds in trout.

The discovery of hæmatitic iron-ore has been long desired by owners of land in Nippenose Valley, but has never yet rewarded search. The ragged outcrops of the harder beds of the limestone protrude too generally above the surface, and the beds of brownish clay, which, if deep enough, might contain ore, are too shallow. Various pits have been sunk for ore, but without permanent success.

In every one of Pence's openings, the solid rock was struck a short distance beneath the surface. The true reason for the absence of ore will probably be found to be the extreme gentleness of the dip of the rocks, and consequent absence of longitudinal fractures, and deep rugged underground hollows or basins needful for affording reservoirs for the ferruginous clays.

Anti's Gap.—Fossils abound in the Matinal black slate in Anti's Gap. The slate is black, weathering a reddish grey, soft, falling into pencil-shaped fragments, and interlaid with occasional bands of slightly-calcareous hard blue sandstone, which multiply on approaching the upper limit of the Matinal limestone formations. Above the ridge the Matinal limestone gradually takes its place, and the dip rapidly declines.

At Bixler's Tavern, in the E. end of the valley, 3½ miles from Anti's Gap, there is a so-called "marble quarry," which affords a hard solid dark-blue limestone, variegated by thin veins and specks of yellow, and sometimes white, spar, and susceptible of a good polish. Its dip is 15° S. 20° E. The same rock might be traced through the valley near its centre line. It appears at

Epler's Tavern, a mile W. of Bixler's, on its N. dip. This variety of limestone is not unusual among the strata of Penn's and Nittany valleys, and something like it occurs in the Scalent limestone group outside of Anti's Gap. In this marble quarry we obtained several *Orthoceratites*, *Trilobites*, corals, &c.

A large sink-hole and cavern, into which a stream dashes and disappears, may be seen one mile S.S.W. of Bixler's. The bold exposures of limestone dip 15° S. 12° E.

A narrow wild glen runs up from Anti's Gap eastward between the two ridges of the Bald Eagle Mountain, and at its upper end, where it rises almost to a level with the land between Nippenose and Musquito valleys, there is, or was, a settlement of several hundred German Catholic immigrants, who by industry and frugality made the comparatively sterile soil of the Levant middle red sandstone available for the means of subsistence.

CHAPTER VII.

SUGAR VALLEY.

Sugar Valley, with its rich limestone floor and heavy forests, averages $1\frac{1}{2}$ miles in width, and is 17 or 18 miles long. The limestone extends to within three-fourths of a mile of its W. end, and as far Eastward as 6 miles beyond Kleckner's. Its width at Friedly's Furnace is still considerable.

Iron ore is supposed to exist in quantity 3 miles W. of Kleckner's, but other openings have failed to yield ore enough to justify the erection of furnaces. About 2 miles E. of Kleckner's the surface is strewn with specimens of dark excellent chestnut ore, among numerous fragments of variegated chert. In every opening the solid rock was struck before descending 15 feet, and shafts 30 feet deep were sunk near the furnace with the same ill-success.

On the road from Rebersburg into Sugar Valley the Levant grey sandstones at first dip 45° N. 28 W., and there, in the middle of the synclinal, we find the complexly false-bedded strata of the argillaceous (red) sandstone in a nearly horizontal position. The Matinal slates, on entering the valley, dip 45° S. 30° E. This is 3 miles from its W. end. Pursuing the road across the valley to Washington Gap, the limestone strata incline continually less, and a dip is perceived lengthwise of the anticlinal as the latter declines Westward. Before reaching the sawmill the dip is 5° S. 40° W. At the sawmill it is 15°, but passing the axis of the flexure as it runs close along the N. side of the valley, the slate and sandstone in the gap are nearly perpendicular, and a little further, even overturned to 70° S. A section of the valley will be represented thus.

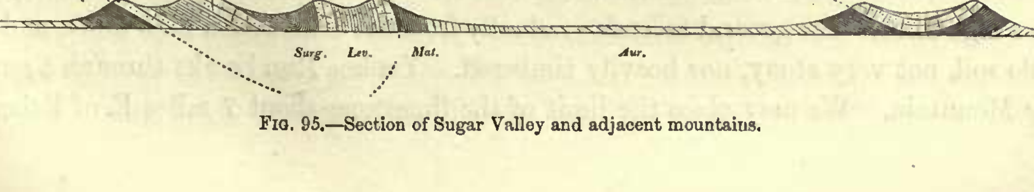


Fig. 95.—Section of Sugar Valley and adjacent mountains.

Corresponding with this position of the anticlinal, the curve of the S. terrace assumes an acute angle with the straight line of the N. terraced ridge.

About 3½ miles from the W. end, upon the main road up the valley, a pale-blue fetid limestone occurs, speckled with yellow spar like the Nippenose "marble." It dips 20°. Sandy limestone in the creek 2 miles further E. dips 15° N. The anticlinal becomes more regular towards the middle of the valley. In Kleckner's Gap the dip is 30° N.

The margin of the limestone recedes a little further from the foot of the mountain E. of Kleckner's Gap. At the furnaces there is a quarry of massive strata dipping 10° N. 20° E., marking the decline of the anticlinal in that direction.

Numerous streams descend through the high N. wall to feed Big Fishing Creek, the head of which is well known under the name of Tea Spring, separated only by a swampy patch from the head of Whitedeer Creek. The Tea Spring is so called from the abundant growth of *Solidago,* or Golden Rod, near it.

CHAPTER VIII.

BRUSH VALLEY.

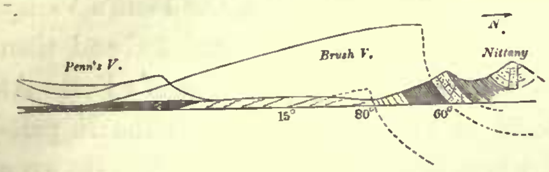
THIS beautiful and fertile valley has a very level limestone-floor. The limestone extends to the foot of the mountain. The slates rise half-way up the mountain-side. The limestone ascends the valley lengthwise to a point 8 miles above the town of Rebersburg, although impure calcareous beds appear one half of a mile further E. The plain at the mouth of the valley, opposite the end of Brush Mountain, is about one mile wide, but the cultivated land rises high upon the slaty slope of the mountain. At Madisonburg (Jacobsburg) the plain is 1½ miles wide, at Rebersburg nearly 2 miles wide. Its wall, or the N. terrace-ridge of Brush Mountain, ranges about N. 70° E., and is much broken by gaps, through which the mountain brooks descend until they sink underground at the margin of the limestone. The farms are supplied with water by a system of pipes from the mountain streams. Attempts to supply Rebersburg by wells have revealed the fact that the limestone is cavernous in all directions, and destitute of water.

No deposit of ore has as yet been discovered to justify mining, nor are the surface appearances such as to inspire a hope of its presence in quantity. Surface-fragments, however, strew the soil in some places to a considerable extent.

Matinal Slate.—About 9 miles from Rebersburg, at the head of the open valley, and for one mile below it, the Matinal slate, with its argillaceous and silico-argillaceous strata, occupies the whole surface, which may be three-quarters of a mile wide. Near this place the curious projection of the Nittany terrace-shaped ridge, a bold knob or mountain-shoulder, narrows the valley to a mere gorge, in which form it continues to its termination, several miles further E., where its sandstone walls unite in a high knob. The ground ascends gradually from the contraction for 3 miles, and possesses an arable soil, not very stony, nor heavily timbered. Yankee Run breaks through a gorge in the Nittany Mountain. We may place the limit of the limestone about 7 miles E. of Rebersburg.

A section made 4 miles E. of Rebersburg, where the valley is about one mile wide, shows the anticlinal axis nearer to the foot of Nittany than of Brush Mountain, the dips being steepest on the N. side. In a large quarry on Elk Creek near the foot of Brush Mountain, the dip is only 10° S. 10° E., in limestone full of fragments of trilobites, shells, zoophytes, &c. This is a good locality for fossils. The gentle dip produces a broad strip of slate land along the foot of Brush Mountain.

FIG. 96.—Section of Brush Valley, looking West.



The anticlinal axis runs about 300 yards to the S. of Rebersburg, lifting the fine-grained blue silicious rock to the surface. The dips along the main road are from 10° to 15°. The anticlinal flexure is perfectly regular in a section made opposite Elk Creek Gap, where, on the creek and 200 yards from the mountain, blue limestone, with calcareous spar, and in silicious black and thinly-laminated layers, dips 40° S. 12° E. The quarry yields good building-material in square fragments. From the axis of the flexure in the centre of the valley, there is first a gentle N. dip, and then no exposure of the limestone until we reach the line of sink-holes along the base of the Nittany Mountain, where a pale-blue very hard limestone dips 30° N. 15° W.; and 200 yards further, the Matinal limestone succeeds with its uppermost or fossiliferous beds, full of trilobites and other fossils, and alternating with black slate, all dipping 40° N.

One of the finest natural exhibitions of an anticlinal flexure to be met with is afforded in a field N. of the main road, within a mile of the village of Madisonburg; the floor of sandy blue limestone is arched and broken by longitudinal fissures, parallel to the axis of the anticlinal or the central line of the valley.

From Madisonburg west the anticlinal becomes sharper, the side-dips increasing, and the lower limestones are disclosed along its central axis. Thus, half a mile from the village, the dip is only 8° N. 35° W. near the road. Three miles distant it is 25° N. 30° W.; 2 miles further, grey crystalline fetid limestone dips 55° N. 20° W., just N. of the road, and within a quarter of a mile from Cook's. At the mouth of the valley, the dip in the road is 40° N. 20° W. Here we enter Penn's Valley, and shall take up the description of it from Short Mountain westward.

CHAPTER IX.

PENN'S VALLEY.

THIS valley is divided at its upper end by Short Mountain, and in its middle region by Egg Hill, a residual mass of Matinal slates capped with Levant grey sandstone, lying in the same synclinal trough with Short Mountain, and with the great spur of Tussey's Mountain. Its most Northern anticlinal crosses the Aaronsburg turnpike $3\frac{1}{2}$ miles from the "Old Fort," with gentle dips 7° N., and within 800 or 900 yards of Egg Hill. Even a mile N. of the turnpike the dip is but 15° N. at the margin of the slate.

George's Valley, lying between Egg Hill and the Seven Mountains, has a soil dark from the decomposition of argillaceous limestones, elevated by a regular anticlinal along its central line. Near the axis the dip is 30° S., but the dips along Egg Hill are never steeper than 10° N.

It is remarkable that the synclinal flexures are generally gentle and broad, but the anticlinal ones abrupt and narrow. The dips observed along the turnpike belonging to the Penn's Valley anticlinal are 51° S. 35° E. in blue massive limestone at the tenth milestone, and 30° and then 20° N. in slightly-calcareous sandstone at the ninth milestone, half a mile S. of Potter's Fort. At the Fort, massive pale-blue fetid limestone dips 27° N. 25° W., and half a mile to the N. pale-blue black-specked limestone, with encrinal rings of white spar, dips 30° S. 30° E. Between these two last dips ranges the synclinal axis of Brush Mountain. The same S. dip 30° is seen at the large and beautiful "fathomless spring" at the head of Penn's Creek, in its encircling walls of limestone.

Anticlinal Axis of Brush Valley.—The axis of the anticlinal of Brush Valley crosses the turnpike within 700 yards of the foot of the Nittany Mountain, for at that distance the silicious rock, already frequently mentioned, dips 17° S.; but 150 or 200 yards from the mountain, where a range of sink-holes crosses the road, the dip is 80° N. In the mountain itself it is 60° N. 35° W. The form of this flexure, therefore, is worthy of remark.

About 2 miles E. from Boalsburg, on the main road Eastward, blue argillaceous limestone, dipping 15° W., marks the vicinity of the Penn's Valley anticlinal. In the Galbraith Gap of the spur of Tussey's Mountain the slate dips 55° S. from the same anticlinal. In the Loop, and S. of the George's Valley anticlinal, the slate dips 12° S. 10° E., and again 50° S. 20° E. The whole of the Loop is floored with outcropping Matinal slate, except a centre point perhaps 100 yards in width, where the road crosses it. The anticlinal of George's Valley and the Loop, therefore, is a sharply-bent or steep wave; that of Penn's Valley exhibits in many places between the Loop and Potter's Fort equally great steepness, 60° S. 30° E. The latter enters Tussey's Mountain between the two spurs; while the next, or Brush Valley anticlinal, runs on at a distance of three-quarters of a mile from the foot of Nittany Mountain. It will appear upon the Map how the valleys and their anticlinals curve in their Westward course towards the S. At Boalsburg, Penn's Valley may be said to lose itself in Nittany Valley, which we now describe, beginning at its head, or N.E. end.

CHAPTER X.

NITTANY VALLEY.

FROM its head to the end of its Southern barrier, Nittany Mountain, this valley has a length of about 31 miles; its breadth varies from 5½ to 2 miles. Its central region is chiefly uncultivated, and goes by the name of "The Barrens," beneath the surface of which lie enormous accumulations of rich iron-ore. This part of the valley is wholly destitute of water. The soil is susceptible in many tracts of a high degree of fertility. E. of Bellefonte 2 miles "The Barrens" become a ridge, marking the main central anticlinal axis of the valley, and attaining at some points of its range considerable prominence, but it is everywhere rather an irregular deeply-grooved high ground than a definite ridge. Hard ribs or outcrops of impure limestone make its contour uneven. It falls away and disappears within 5 miles of the Millhall Gap, beyond which the floor of the valley is gently undulating, except near the bases of the mountains, where the ravines are sharp and deep.

The great anticlinal flexure of this valley has its S. dips gentler than its N. ones ; its axis lies, therefore, nearer to the Northern than the Southern side, ranging, however, into the central line, toward the head of the valley. Opposite Millhall it runs 250 yards further to the N.W. than the centre. Opposite Jacksonville, it is about $1\frac{1}{2}$ miles from the base of the Bald Eagle Mountain, and is not much further off opposite the end of Nittany Mountain.

The Matinal slates bordering the great plain of Auroral limestone, and containing among their lowest beds some argillaceous limestones, ascend the sides of the Nittany and Bald Eagle mountains about two-thirds of their slope.

Section opposite Millhall Gap.—Big Fishing Creek issues from Nittany Valley by the Millhall Gap, and flows into the Bald Eagle Creek. Denudation has swept away the first or inner ridge of the mountain for three-quarters of a mile on the S.W. side of the gap. The lowest Surgent rocks seen are the soft green iron-specked sandstones of the Levant red sandstone. At the forge the rocks dip 70° N. The Matinal slates are not seen in place, but nearly all of the Auroral limestone is exposed along the E. side of the creek for half a mile, with a general dip of 8° N., until at the S. side of the village of Salona it is reduced to 3° N., which continues for a quarter of a mile. The surface is covered with chert. The next good exhibition of the limestone is one mile from the base of the Nittany Mountain, the dip being 20° S. 30° E. In Finley's Gap the Levant sandstones dip 15° S. 35° E. The whole valley is here about $2\frac{1}{2}$ miles wide. The Matinal black slates in the gap are black, calcareous, and fossiliferous, mixed with argillaceous limestone beds, underlaid by a great thickness of the Matinal limestone in the form of light-blue conchoidal fine-grained fossiliferous strata. Beneath this last-named are the Auroral limestones; these are bluish-white, fetid, semi-crystalline limestones, weathering rough, succeeded in descending order by pale-blue limestones, these by thin beds full of white calcareous spar ; and further down, sandy and silicious limestones preponderate. The dip is 60° N. 25° W.

Below the rocks last mentioned, and composing the hill which runs to the S. of Salona, there crops out a pale-blue sandstone of a very fine and conchoidal grain, looking much like a limestone. It is a very persistent rock in the series, appearing throughout this and all the neighbouring Matinal valleys. The width of the belt being about half a mile, and its dip steep, its actual thickness must be great, and the recognition of its presence important ; for although a few of its beds are calcareous, none are fit for conversion into lime.

The pale-blue variety of the limestone of Millhall Gap is recognisable again on the opposite dip 18° S. 30° E., 200 yards S. of McRobin's house, and outcropping over cherty calcareous sandstone.

East of the section, on the road leading from Salona to the head of the valley, silicious limestone dips 5° N. at the Ore Diggings, half a mile from the village. For $3\frac{1}{2}$ miles to Furst's, the valley is quite level ; the tillable land is there about $1\frac{1}{2}$ miles wide. Gentle dips abound, and the dark soil of the upper fossiliferous limestone, or Matinal limestone, abounds towards each mountain, the silicious rocks having gone under. At Snyder's, half a mile further, and also in the centre of the valley, light-blue conchoidal limestone occurs. One quarter of a mile further the slates close over the anticlinal axis. In a gap opening S.E. into Sugar Valley, the Matinal black slates abound in trilobites and fragments of *Orthocera.* They are interstratified with hard, fine, blue, somewhat calcareous sandstones. The stream descends by a deep ravine from the Nippenose plateau through rocks dipping 5° or 10° E.

At Fleming's Gap in the Bald Eagle Mountain there is but a notch in the inner or terrace ridge, but the drainage between the ridges flows out of a deeper gorge in the outer or Northern one. Such gaps are numerous in this mountain to the E.

West of the section the silicious band of the Auroral limestone series forms a hill extending from McRobin's, on the S. side of the valley, to Riesman's stone quarry on Fishing Creek. The stone is very hard and fine-grained, and makes an excellent building-material. Both pale and dark-blue good limestone dips beneath it, 10° S. Chert occurs in rather massive beds in the same exposure. The crest of the anticlinal wave appears to be absolutely horizontal 3 miles W. of Salona.

Section at Washington Gap.—A section was surveyed 6 miles W. of the former, from Washington Gap across the valley. For 300 yards from the furnace towards the mountain, in a distance of 1000 yards, light-blue silicious strata occur interstratified with a few bands of pure limestone, dipping 33° S. 43° E. On the creek, above the silicious beds, appears a beautifully-blue conchoidal limestone; and one-fourth of a mile higher up is another exposure of good blue limestone; and then the fossiliferous Matinal limestone begins, and continues to crop out nearly to the foot of the mountain. A dark-grey slaty sandstone is seen in the gap among the Matinal slates, with included hard grey silicious limestones, all dipping still 30° S. 45° E. Further within the gap are massive red, succeeded by compact white sandstones, of the Levant group.

One mile N. of Washington Furnace, where the turnpike crosses the creek, we meet the silicious strata. Beneath them, at a distance of 100 yards, comes up a band of good blue limestone veined with spar; and from beneath this many cherty strata, the fragments of which cover the ground for three-fourths of a mile. The sandstone is an uncemented agglomeration of quartz, and appears to belong to the Matinal calcareous sandstone. Passing across the high ground of the sandy barrens, the section strikes the ore-banks 2½ miles from the furnace. The ore and limestone dip 45° S. The Bald Eagle Mountain is 1¼ miles distant. Silicious fragments cover the ground for half a mile, to a point where the rock in place dips 55° S. 40° E., being no doubt overtilted to this extent; and one-fourth of a mile further, good spar-veined limestone stands vertical.

Section near Jacksonville.—A third section was compiled near Jacksonville, through which Lick Run issues to the Bald Eagle Creek. The village is on the "north" road, and one-fourth of a mile from the Bald Eagle Mountain at Howard's Gap. The silicious strata exhibit themselves just S. of the tavern, dipping 65° S. 40° E., being overthrown. Near the tavern, pretty good pale-blue fetid limestone outcrops, with inversion dipping 60° S. Toward the Bald Eagle Mountain the fossiliferous Matinal limestone appears, and within 100 yards of the mountain there is a so-called "coal opening" in the black calcareous Matinal slates, where the owners, misled by slate, beautifully polished by a sliding movement of the strata at the period of their uplifting and bending, have at times wasted money and enterprise in a vain search for coal.

At Jacksonville, the silicious layers, or sandy magnesian limestone, dip 70° S. 39° E., and so also, where they appear interstratified with common sandstone strata, one-fourth of a mile from the village. All the strata visible between the road and the Bald Eagle Mountain, one mile W. of Jacksonville, dip on an average 80° S., but S. of the road the silicious rocks dip 53° S. A fossiliferous massive blue limestone, containing trilobites and abundance of crystallised black carbonaceous limestone, and a few small pebbles of reddish calcareous spar, exhibits in a quarry upon the top of the N. escarpment of the Barren Ridge a dip of 25° S. 45° E. The dislocated axis of the Great Nittany Valley anticlinal flexure ranges, therefore, to the N. of Barren Ridge, and parallel with it. It is to be regarded as an "upthrow on the S.," bringing to the surface the base of the Auroral, and past the edges of higher Auroral rocks in the wall of the fissure, the upper beds of the Primal series. S. of the "Barren Ridge," and within one mile of the Nittany Mountain, is a thinly-bedded and black sparry limestone, interstratified with silicious layers, dipping 30° S.

The top of the first ridge of "The Barrens" is formed of sandstone, blue and white, compact and crystalline, dipping about 25° to S. 40° E. This ridge is ravined into a succession of rounded knobs. Limestone outcrops on the second higher ridge, on the N. slope of which sandstones dipping 25° to the S. crop out. It is probable that no stratum really belonging to the Primal series rises above the surface, but that the sandstones visible on the N. slope of the central ridge are interstratified among the lower beds of silicious magnesian limestone, and are truly the Auroral calcareous sandstones, the equivalent of the "calciferous sand rock" of New York.

Section at Hecla Furnace.—The next section surveyed crosses the valley from the Mount Hecla Furnace, in the gap behind which the dip is 45° to the Southward. The valley between the mountain and the Barren Ridge is very level. About three-fourths of a mile from the mountain, the silicious rock is quarried for flagstones for the town of Bellefonte. It is of a deep-blue colour, and dips 40° to S. 30° E. A subordinate anticlinal flexure may be seen in this part of the valley. Near M^cKinney's Ore Banks at the base of the "Barrens," the rocks, chiefly non-calcareous, dip 22° to the S. Impure blue and rather coarsely-laminated silicious magnesian limestones outcrop in the N. slope of the central ridge at an angle of 10° S., in cliffs of 20 feet or more in height. This is about $1\frac{1}{2}$ miles from the Bald Eagle Mountain. On the N. road the silicious rock stands perpendicularly, and pure limestone rises to the N. of it.

Nearly 3 miles from Bellefonte, the Matinal slates stand vertical in a gap in the Bald Eagle Mountain. In this immediate vicinity there are beds of hydraulic limestone enclosed between strata of good common carbonate of lime; and 2 miles from Bellefonte excellent limestone is quarried, dipping 60° N. 30° W. Many other exposures, all with steeply North-dipping strata, are passed in approaching the town.

The division of the valley which lies to the N. of the central ridge presents a striking contrast to that upon its S. side. It is much ploughed into deep ravines, while the other is level and unbroken. This difference has arisen from the superior denuding effects of the eroding currents when acting upon vertical strata, compared with their influence upon strata inclined at angles within the limits of 30° and 60°.

Section of the Valley at the Bellefonte Gap.—The next *section* made was compiled from localities opposite the Milesburg Gap. It crosses very uneven ground, but no regular ridge like that of the Barrens, the latter having disappeared with the fault which caused it. Blue fetid limestone interstratified with some silicious beds, and dipping 45° N.W., crops out on the creek below the

Bellefonte bridge. The silicious formation so often mentioned rises from beneath it near the new Presbyterian Church, and may be observed in the lower part of Main Street of the town. Small angular pieces of pale-red flint occur between the layers, where they dip 62° N. 35° W. opposite a large mill on the creek. The rock along the creek becomes sometimes a coarse blue sandstone, with crystallised quartz. The limestone, soon appearing, is at first blue and sandy, but increases in beauty of fracture and clearness of colour, and becomes veined with calcareous spar as we proceed upward in the series towards the mountain-gap. At the first lock it has become not only argillaceous, but slaty, dips 80°, and is full of fossils. The sandstone in the gap dips 70°.

Limestone is seen upon the turnpike dipping 30° to the S.E. The abnormal direction in the dip can either be explained on the supposition of a very sharp small fold or local double flexure, or on that of a great dislocation. Appearances are in favour of the former conjecture.

From the town, going S., the section exhibits first a sandy limestone dipping 33° N. 35° W., and full of numerous small cavities, casts of shells, and fossil corals. One-fourth of a mile beyond the village, disturbances in the strata and numerous cross-fractures cover a zone of three-fourths of a mile of outcrop, mostly North-dipping; then South-east-dipping rocks appear, and continue inclining about 15°, and in the Nittany Mountain even less.

Cement layers occur on Spring Creek, 1½ miles from Bellefonte, and when slowly * burnt yield good hydraulic lime.

Section across the whole Valley, half a mile W. of Nittany Mountain.—From the Bald Eagle to the Nittany Mountain is about 6 miles, one-half of which space is occupied by the uncultivated central tract of rolling Barrens. The ore-banks of this region are numerous, and will be mentioned hereafter. Fulton's Gap is a breach in the southern Bald Eagle Ridge; only the glen of Levant red sandstone between the two ridges is cultivated. About 200 yards from the mountain occurs blue fetid veined sandstone, dipping 80° to 85° N.W., but the inclination diminishes so rapidly that at a place half a mile from the mountain it is only 20° N.W. Thence to the edge of the Barrens is 200 yards, and 300 yards further, the grey silicious rock dips 7° N. 40° W. Three-fourths of a mile further, the lower limestones are seen coming up with a dip of 5° N.W.; and one-fourth of a mile further, sandy limestone specked with black calcareous spar, dipping 6° S. 20° E. The axis of the flat anticlinal may be said to run, therefore, at about 1½ miles from the Bald Eagle Mountain.

A deep hollow, probably continuous, ranges across the line of section at 3½ miles from the mountain. It contains a limestone like that on the brow of the Barrens in the Mount Hecla section. It dips 10° S. 40° E. Further S.E. more massive and better beds dip 15° S. 35° E.

South of the Barrens, the silicious rocks descend with a dip of 20° S. 40° E.; with these appear good limestone-beds on the hill N. of Centre Furnace, showing by a dip of 20° S. 65° E. the shoaling-up of the Nittany Mountain synclinal. Round the end of the mountain, sweep the Matinal slates mixed with silicious micaceous beds. On the S. side of the synclinal, the fossiliferous limestones dip steeply toward it, 60° N. 20° W. Prolonging the section across the mouth of Penn's Valley, we find the silicious rocks appearing 400 yards beyond the last exposure, and

* A layer of charcoal is spread at the bottom, on this a layer of cement stone, and on this a layer of stone coal. These triple layers, repeated in the same order, fill the kiln. The burning is continued until the mass is of a dull straw-colour.

dipping 47° N.N.W. The dip changes to 8° S.E. at the first mile beyond the sawmill and foundry. This anticlinal axis, which is that of Brush Valley, ranges therefore a mile from Boalsburg, and as far from the Nittany Mountain. Boalsburg is half a mile from Tussey's Mountain. The S. dip of 8° soon increases to 15° and 25°, and is 30° at 400 yards S. of the village, in blue limestone susceptible of a good polish.

CHAPTER XI.

THE IRON ORE-BEDS OF THE NITTANY VALLEY.

All the ore-diggings of the Nittany Valley are made in the central region called "The Barrens," and in proximity to the impure limestone-beds called "Curly Back;" some at the S. foot, a few on the summit of the broad sandy ridge.

There seems to be a fixed relation between the ore and the part of the formation, or the character of the rocks lifted to the surface by the flexure, and between it and the depth of the ferruginous earth, which itself is dependent on the extent of deposition during denudation.

E. of Salona, ineffectual attempts were made to follow good honeycomb ore, lying in a crevice between the strata; when struck by a shaft 60 feet below the surface, it was mixed with much sulphuret of iron. Cellular ore in vein was once opened on Mr Brexler's place. No other ore has been discovered, the limestone everywhere just underlying the surface soil.

The Washington Bank is 2½ miles from the furnace, and on the N. side of the Barren Ridge. It is one of the best and oldest of the excavations in Nittany Valley. In 1838 it had been opened ten years, and was 800 feet in length. Two veins of pipe-ore, and a third of a less regular variety equally good, dip 45° S. 40° E. Impure sandy limestone (curly-back) dips with ore in one part of the diggings.

The Lamar Bank adjoins the last on a tract of 8 acres, and yielded, when worked, hard ore in compact masses. Pipe-ore occurred in one vein only 12 inches thick.

Nathaniel Beck's Bank was not then wrought.

Harris's Banks are 1½ miles E. of Jacksonville. One of these was 150 feet in length and 100 feet broad, and on slightly-rolling land, strewn with specimens of poor brown ore and silicious fragments. Alternations of ore and white clay were to be seen in the sides.

Harris's Bank, on Wm. M^cCalmont's land, yielded, in 1838, 40 tons of good pipe-ore daily, by a shaft sunk 25 feet through white and yellow clay to reach the ore, which was of unknown depth. The vein of ore pitched steeply N. Another shaft was sunk 100 feet through clay before striking the ore. Specimens of "pipes," or stalactites of the iron ore, 3 feet long, and perfectly formed, had been extracted, but no limestone-bottom was seen. It will be remembered that this deposit occurs S. of a dip of 58° S.E. in the silicious rocks, and N. of a dip of 45° N.W., or apparently between two sharp anticlinals.

John Beck's Bank, on the S. side of the Barrens, yielded good pipe-ore, dipping 30° S.E. between massive white-grained silicious limestone, through which two shafts, 50 feet thick, were sunk to strike it.

Harris's Bank, 2 miles N.E. of Mount Hecla Furnace, was mined by a shaft sunk through red sand 8 feet, and white clay 12 feet, to the mass of "fine" ore—like a brown gravel—becoming a solid rock of pipe-ore below, and dipping 45° N., penetrated at the time seen only 8 feet deep. Two drifts 100 feet long were run upon the fine ore. One shaft struck solid silicious rock at a depth of 30 feet, dipping N.

Mount Hecla Bank, near the last, had, in 1838, supplied two furnaces for twelve years, and was, when seen, 200 feet long by 40 deep. Drifts had been run upon pipe-ore veins from 2 to 5 feet thick. The mass of ore consists of detached lumps and pebbles of black oxide of iron, imbedded in a ferruginous loam. Small beds of red oxide of iron occurred, and also an argillaceous oxide, brown and yellow in alternate layers, like some varieties of stalagmite. Masses of black clay coloured with vegetable matter were to be seen with the white clay.

M^cKinney's Bank, opposite Mount Hecla Furnace, and three-quarters of a mile S. from the summit of the Barren

Ridge, yielded, over a space of 2 acres, small masses of ore in clay, and within less than 2 feet of the surface. One shaft was sunk through clay 3 feet, ore 22 feet, and white clay and sand 20 feet. One variety of ore was a dull-brown oxide, not in the pipe form; the other existed in oblong round balls, containing frequently pure alumina, and sometimes water, and lined within with scales of black hæmatite. The latter variety was estimated to be 4 feet in thickness, and made excellent iron. The vein dipped to the N., while, 300 yards N. of the bank, rocks were observed dipping 22° S.

Curtis's Diggings, 5 miles N.E. of Bellefonte, on the summit of the Ridge, yielded nothing valuable at the time of our survey.

Gatesburg Bank is 2½ miles from Bellefonte. A shaft 150 feet deep in the centre of an excavation, 120 feet long by 40 deep, yielded pipe-ore for a time. The ore lies between the irregular limestone layers in the walls of the great excavation.

Valentine's Bank is on the hill back of the furnace, S.W. of Bellefonte. It contained pipe-ore between the strata of sandy limestone, and reached the same kind by a shaft, blasted down through 150 feet of rock, to a cavity 16 feet wide and 60 long, in walls of limestone and stalagmitic concretions.

Lamborn's Bank, 4 miles from George Williams', and near the ridge of the Barrens, yielded inferior solid ore, used at Juliana Furnace, where it was mixed with Pond Bank ore in the proportion of one to two.

Pond Bank, 2½ miles S.W. from Williams', on the summit of the Barrens, yielded an ore, described as the second variety at McKinney's Bank.

Edmiston Bank, half a mile S.E. of Williams', on the N. side of the Barrens, furnished pipe-ore. The deepest shaft was sunk through red clay 30 to 40 feet, then in loose rock, next in solid sandy limestone, then in a vein of pipe-ore 70 feet beneath the surface, and from 6 to 8 feet thick. Beneath this ore the limestone strata were standing vertically, with veins of ore between them, which were followed until the shaft was 140 feet deep.

CHAPTER XII.

NITTANY VALLEY (CONTINUED).

For some miles S.W. of Boalsburg, the Tussey Mountain terrace, or subordinate ridge of Levant grey sandstone, is as high, or even higher, than the main crest of the Levant white sandstone, but further on it sinks to its proper secondary altitude, and is broken by a succession of gorges from half a mile to 1½ miles apart. As we approach the Little Juniata, the strata are more entirely denuded of the superficial matter, no deposit of clay and loose fragments lying on the N. slope, but the sandstones outcrop boldly. At Sligo Forge they compose a precipice 200 feet in height, and in the Juniata Gap they are overturned, dipping 25°, 30°, and then 45° S. 50° E. Between the two Juniata gaps the terrace is wholly swept away, and S.W. of the main Juniata gap the river flows along the outcropping middle formation, or Levant red sandstone, in a trough, which cuts off the terrace from the main crest, and causes it to terminate in abrupt precipices of grey sandstone, one of which may be seen at the hotel at Water Street.

Few exposures of the Matinal slates are discernible between Boalsburg and the Juniata. An opening for coal was long ago made on Spruce Creek, near Wigdon's Forge, in the Matinal black slate, in pyritous non-fossiliferous layers, dipping 60° S. 55° E. An opening for silver was made at a still earlier date near Colerain Forge, in the alternating black slates and argillaceous limestones of the Matinal limestone formation. Above the black slate there is a thickness of about 250 feet of coarse olive slates dipping 50°. On the Big Juniata, near the toll-gate, the crushed slates stand nearly vertical.

Between the slates at the base of Tussey's Mountain and the uncultivated broken and sandy land that covers the axis of the anticlinal, as do the Barrens that of Nittany Valley proper, there extends a belt of cultivated land, from $1\frac{3}{4}$ to $2\frac{1}{2}$ miles wide. The broken land is covered with scrub-pine and oak, and presents few exposures of the rocks, and those that do appear belong to the lowest Auroral limestones. The sandhills are strewn with fragments of sandstone, silicious and dark-grey limestone, ferruginous rocks, iron ore, and rugged cellular quartz-rock. S.E. of Stormstown or Walkersville, the first high range of barren hills is covered with fragments of rocks, exactly resembling the loose fragments covering the flanks of the Levant sandstone mountain. The rock is not exposed in place, but belongs probably to the Primal series, brought to the day at the axis of the anticlinal flexure.

This more Southern range corresponds in all its essential features to the Barrens of the Nittany Valley. The wide synclinal region between them may be described as a desolate country of confused hills and hollows of all sizes and shapes. Sometimes the chain of barren hills is interrupted for a space, and the fertile side-region rises into a table-land, furnished with a high watershed along the central synclinal axis. On other cross sections, four rude chains of hills may be seen stretching along the axes.

The Auroral limestone, in fossiliferous thin grey layers dipping 24° S. 35° E., is well seen in the quarries three-fourths of a mile N.W. of Boalsburg. The dark-grey silicious layers dip 26° at a quarry $1\frac{1}{4}$ miles to the N.W. In the flat fertile land S.W. of Boalsburg, solitary outcrops are numerous, and generally display a dip of about 40° S.E. The mountain-streams between Boalsburg and Pennsylvania Furnace sink into a cavern on this elevated watershed of the Susquehanna and Juniata. Spruce Creek issues from a cavern three-fourths of a mile from the mountain, where massive blue limestone dips 18° S.E. Magnesian limestone strata outcrop in a ridge 300 yards to the N. This whole limestone range becomes more broken up towards the Juniata.

Good and prolonged exposures of the rocks may be studied at the Pennsylvania Furnace. Blue massive limestones dip 35° S. 20° E.; and milk-white chert occurs in thin twisted beds. About three-fourths of a mile to the N.W., and $1\frac{1}{4}$ miles from Tussey's Mountain, white sandstone dips 35° S. 30° E. Blue silicious limestone and grey sandstone rocks are exposed along Half-Moon Run, dipping 30° S. 25° E., and then 15° or 20°, and finally 40° N. 35° W., within three-fourths of a mile of its mouth. This is the position, therefore, of the southern Nittany Valley anticlinal. Spruce Creek offers frequent exposures, 40° or 60° S., 30° or 40° E., as it winds in a rather deep ravine towards the Juniata. Such may be seen at Gates' Forge, in the middle of the Auroral limestones; also at the Bluff, $1\frac{1}{2}$ miles from Colerain Forge; and again near Wigdon's Furnace, in the upper very fossiliferous Matinal limestones. The soil along the edge of the Barrens is full of rough lumps of vesicular chert, and of beautiful crystals of quartz. Warrior-Mark Run traverses the whole valley, and exposes the structure of both anticlinals. At Colerain Mill, near its mouth, and 500 yards from the mountain, massive blue limestone dips 45° S. 50° E.; and 500 yards higher up the Run, dark-blue and grey limestone appears; and half a mile further yet, a light yellowish blue variety, with much cleavage, dipping 45° S. 60° E. The anticlinal is then passed; for, 400 yards higher up, silicious and magnesian limestones dip 38° N. 60° W. And 400 yards further, in the deep gorge at the Huntingdon Furnace Sawmill, blue and grey calcareous sandstones, near the bottom of the Auroral series, are to be seen dipping 45° N. 70° W. A blue, rusty, porous, calcareous sandstone forms a bold cliff 400 yards further up the stream, or $1\frac{1}{2}$

miles S.E. of the furnace ; and three-fourths of a mile beyond this, at another mill, the rocks of the Nittany anticlinal appear, dipping 20° S. 30° E.

At the gap of the Little Juniata there are evidences of an interesting fault or great displacement of the strata. On one side of a longitudinal ravine, the argillaceous or Matinal limestone dips 50° N. 35° W., and on the other side, only perhaps 150 feet distant, the lowermost beds of the Levant grey sandstones dip almost 90° S. 50° E., all the Matinal slates and shales disappearing in the dislocation.

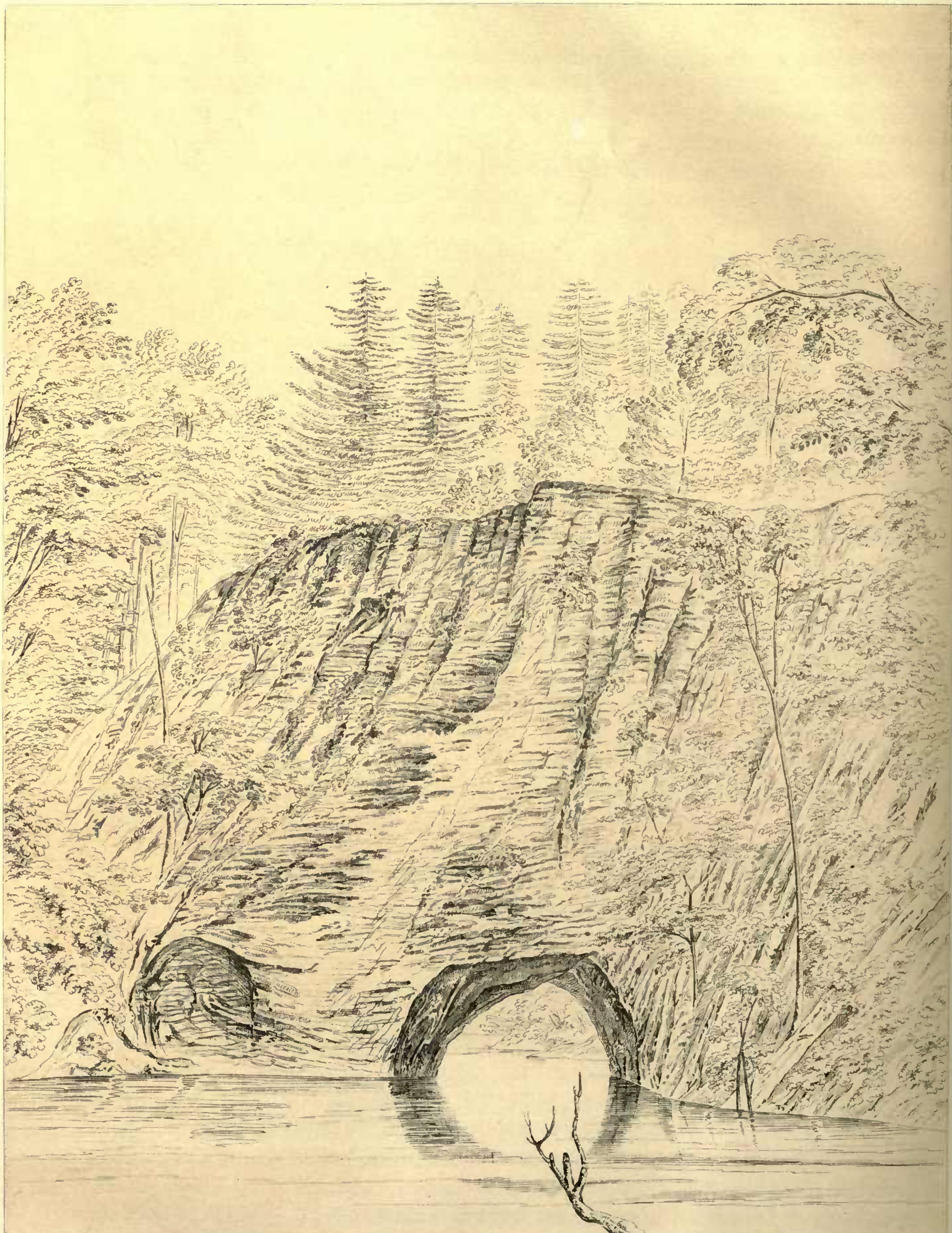
Good exposures occur in a space of about three-fourths of a mile, between the mouth of Spruce Run and the entrance of the gap. The dip is generally 45° S. 55° E. Grey massive limestones, 250 yards above the mouth of Spruce Run, dip 40° E. ; but still higher up the Little Juniata there are numerous exposures of dark-grey and blue magnesian limestone, thinly bedded, dipping 40° S. 60° E. Light-blue cherty limestone crops out where the river bends to the S.W., and 300 yards above this point there occur light ash-coloured silicious and magnesian cherty rocks, weathered to a "herring-bone" surface, or looking as if covered with hieroglyphic markings, the more silicious sort delicately striated with long and parallel lines.

At Wallace's Old Mill, one-fourth of a mile further, the dip is 37° N. 80° W. ; and one-fourth of a mile above the mill a rough calcareous sandstone crops out in a cliff, and under it a massive magnesian limestone, all dipping 40° N. 80° W. Fine exposures of massive blue limestone occur 200 yards below Union Furnace, dipping 45° W. 10° S., and at the furnace the dip is due W. At the upper end of the island the dip is 60° N. 60° W., in massive blue limestone, and near the central line of the synclinal basin, for the next dip seen one-fourth of a mile further N.W., is to the S.E. These exposures are N.E. of the end of Canoe Mountain, distant $1\frac{1}{2}$ miles. At Mr Wallace's house, at the foot of the mountain, the upper limestones dip 40° W., and again 35° S. 25° W., the line of bearing, if prolonged, striking the middle of the Short Mountain.

The Nittany Anticlinal continued Westward.—Few exposures reveal the South-east-dipping rocks of this flexure between Walkerville and the Little Juniata. The rocks on the N. side stand nearly vertical at Walkerville ; they even dip to the S. 65° E. This bearing continues to a point 3 miles beyond the Tyrone Gap.

The surface of Half-Moon Valley is level, varying from 1 to $2\frac{1}{2}$ miles in width between the base of the Bald Eagle Mountain and the first range of barren hills, and consists of excellent farming land. Approaching the Juniata, the waters, sweeping sideways towards the great transverse valley of the river towards the two gaps in the Tussey Mountain, have ploughed that portion of the valley very deeply, and trenched the barren hill-country to the S. to a still greater extent. The high range of hills E. of Birmingham, called Blue Hill, slopes off into flat barrens, and its anticlinal structure is laid bare by the river. It terminates in the undulating plain of Sinking Valley. Between this and the Bald Eagle Mountain, to the E. of the river, is a deep irregular hollow instead of a cultivated flat plain. In Sinking Valley, also, the chief denudation took place at the base of the two enclosing mountains, and along these lines flow the present streams, deeply sunk beneath the level of the central tract.

For some distance W. of Tyrone Gap, the vertical or overturned posture of the rocks continues, accompanied near the axis by gentle dips—namely, 25° or 40° N.W. ; but the inclination along another line of section, $2\frac{1}{2}$ miles further W. of the gap, is regular and general, varying from 40° to 65° N., 60° or 75° W. Sinking Creek rises at the head of Sinking Valley, runs along the outcrop



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NATURAL BRIDGE, CANOE VALLEY Pa

of the slate, disappears in a cavern, reappears and disappears again, and is seen in a series of beautiful blue pools, surrounded by limestone walls. It appears at the Arch Spring,* and again vanishes, not to rise again until it falls into the Juniata. Some of these sink-holes are pits 90 feet deep, walled in by perpendicular cliffs. They range along the outcrop of a massive pure blue soft limestone, about one-third of the thickness of the Auroral series from its upper limit. The rock abounds in fossils. The magnesian and silicious strata, lower in the series, being less soluble have furnished fewer such underground conduits for the waters.

The dip of the strata at the end of Canoe Mountain is almost at right angles to the axis-line of its synclinal flexure. This is due to the rapid rise of the synclinal toward the N.E., visible upon the Map in the blunt convergence of the Levant sandstone mountain.

Section passing Birmingham.—The section exposed from Union Furnace N., in the banks of the Little Juniata River, is as follows : Thin blue limestone 48° S. 50° E. Interval of 150 yards ; massive pure blue limestone. Interval 100 yards ; massive dark-blue limestone, 35° S. 45° E. Interval 25 yards ; massive blue limestone. Interval 100 yards ; dark-blue limestone. Interval 50 yards ; massive pure limestone, 35° S. 60° E. Massive and thin alternations for 250 yards ; interval 100 yards. At $1\frac{1}{2}$ miles from furnace, blue and grey limestone strata in a cliff 300 feet high. Interval 200 ; thin grey limestone, 36° S. 50° E. Interval 30 yards ; dark-grey silicious strata. Interval 200 yards ; light-blue cherty silicious limestone, weathering yellow 33° S. 30° E. for 60 yards. Interval 70 yards ; light ochreous impure limestone. Exposures for 200 yards of dark-grey silico-calcareous rocks, becoming more silicious on approaching Robinson's Sawmill. Just below the mill-dam are interstratified sandstone beds. Dark-grey calcareous beds dip at the dam 50° S. 30° E. Interval 100 yards to a noble cliff-exposure of the massive calcareous silicious rocks, 38° S. 39° E. Eighty yards along this cliff are seen grey, granular, calcareous, silicious strata. Interval 400 yards ; sandy limestone, 25° S. 35° E. Interval three-fourths of a mile to Birmingham. Irregular massive white-veined limestone dip steep to S. 40° E., from beneath which comes up the Matinal black slate full of white veins. Above this a few rods, broken silicious limestone dipping 50° S. 50° E. In the hollow above Birmingham, cherty calcareous rock, with a confused dip S. 50° E. About 150 yards above the Matinal black slate appears a crushed sandstone, like the Levant grey sandstone, succeeded by red shale, soon coming to a regular dip of 35° to S. 50° E., and exposed for 150 yards often in massive strata. Fragments of this sandstone follow. This is upheaved along the fault nearly three-fourths of a mile from Birmingham ; and 150 yards below the bridge, thin blue limestone-beds dip 45° S. 50° E. for 60 yards, becoming steeper, or 80°, and more massive, and veined like a marble. Distorted and horizontal dips succeed. Near the bridge the strata stand vertical. Interval 40 yards, blue thin limestone, 85° S. 60° E. Interval 75 yards, light grey with ochreous surface, vertical. Interval 75 yards, dark silicious rock, vertical for 100 yards. Interval 350 yards, 85° S. 70° E. Interval 370 yards, dark-grey hard limestone, 45° S. 60° E. (overturned) at Ironsville. Immediately behind the village, light buff limestones dip 48° S. 65° E. Pure blue limestone, massive and fossiliferous, appears below the Tyrone Forge Bridge, 65° S. 60° E. (overthrown). Vertical limestone beds appear on the end of the hill opposite the lower forge, dipping 85° S. 65° E. Matinal slates appear 300 yards further N., at the base of the mountain, and vertical ; and 900 feet above the forge are the last exposures of the limestone, alternating with Matinal slate.

* See the sketch of the Arch Cave or Spring near Isett's Mill.

Fault.—The above details afford no clue to the true thickness of the formations, as the course of the river is very irregular, but they serve to mark the general order in which they appear. The anticlinal is a folded flexure, and it is obvious that a dislocation ranges along the line of its axis past the village of Birmingham. The slates and massive sandstones mentioned as in the middle of the section, must belong to the upper part of the Primal series pressed upward and forward, and forming the S. wall of the dislocation.

CHAPTER XIII.

CANOE VALLEY; OR NITTANY VALLEY (CONTINUED).

THE Southern anticlinal of Nittany Valley continues past the end of Canoe Mountain, and between it and Tussey Mountain, lifting the Auroral rocks along Canoe Valley. Canoe Valley, at first a simple anticlinal, widens 6 miles S.W. of the Juniata, by the termination of the synclinal loop in Tussey Mountain, and the continuation of that mountain upon the S. side of an anticlinal, which issues by a cove from Stone Valley.

Subordinate Axis of Tussey Mountain.—A section across this cove at its mouth exhibits a thin anticlinal tongue of Auroral limestone in the centre, and Matinal slates dipping from both sides of it with great regularity, at an inclination of 45° N. 35° W., and S. 35° E. Continued N.N.W. across the synclinal between the forgoing anticlinal and the Canoe Valley anticlinal, and beyond the end of the knob of Tussey Mountain, the section displays the Matinal slates dipping to S. 60° E. at an angle of 40°.

Tussey Mountain runs nearly S. 50° W. for many miles, with an irregular, notched, and undulating summit, and a terrace even more wasted and ravined. Indeed, it is in some places almost swept away, as the annexed outline of the mountain will show.

FIG. 97.—Tussey Mountain Terrace, cut down by erosions.

The main crest-rock frequently projects its masses along the summit like a comb, dipping 55° S. 60° E. The Canoe Valley anticlinal enters a cove heading Southward in Tussey Mountain, and issues through its point towards the Warrior Ridge near Yellow Creek. The first gap beyond this cove to the S.W. is Reber's Gap. Between this gap and that of Yellow Creek the mountain is high and regular, with a uniformly-ravined terrace, and so the mountain maintains a nearly constant dip of 45°, having caused a very even amount of resistance along its whole course.

The N. barrier of Canoe Valley, Canoe Mountain, suffers an up-throw to the W., within a few miles of the Juniata River, which expands its summit, and curves its flank, throwing it towards the W.; but a little to the S. of this an oblique fracture, with down-throw towards the W., or up-throw towards the E., brings the mountain further into the valley than the line it occupied at first. A little glen or gap runs in behind this broken Eastern end, and carries the turnpike road through it. The river goes through the ridge by an ordinary gap still further W., isolating the broken end, which is called the Short or Eastern Lock Mountain. Beyond the river, Canoe Mountain, now Lock Mountain, extends onwards with a regular crest to its synclinal angle at Martinsburg, with its strata in a nearly vertical position.

The Matinal slates are exposed at the gap of the Juniata, at Cove Forge, and in the bend of the mountain, where grey sandstones in the line of the synclinal axis cap the ends of two spurs from the Tussey Mountain terrace, effected by denudation, and formed of slate. This is a good instance of the influence of these curves, in the ranges of hard rocks, upon the denuding action. The anticlinal does not bring the limestone to the surface 2 miles W. of the mouth of Clover Creek. The distance from mountain to mountain, across Canoe Valley, at its Northern mouth, is less than 2 miles.

The Matinal Shales are only 300 yards from the base of Canoe Mountain, dipping 48° W. 20° N.; and 200 yards further, at Davis' Sawmill, the Matinal limestone, alternately slate and limestone, dips vertically. Along the centre of the valley the silicious rocks outcrop, and dip 70° S. 70° E. In the space between these last-cited exposures great confusion is manifest. Magnesian limestones dip 45° S. 65° E., 300 yards from the base of Tussey Mountain.

Along a stream crossing the valley further W., the S.E. dip ranges from 30° to 60°; the N.W. one is vertical. Fine exposures of thick-bedded blue limestone occur at Mr Deane's; sink-holes and a cavern follow its outcrop. The distance to the base of Canoe Mountain is perhaps three-quarters of a mile. Within 70 yards are beds dipping 38° S. 70° E.; the anticlinal lies between. Only the upper third of the Auroral limestone, therefore, is brought up along the valley at this its narrowest point; but lower rocks come up as the valley widens towards the S.W., and barren hills, and clay, sand, and chert reappear upon the surface along the axis. The chief expansion begins to take place 6 or 7 miles from Water Street. A hollow intervenes between the central hills and Canoe Mountain, and in it exposures show vertical rocks. The river, flowing between the central hills and Tussey Mountain, causes numerous good exposures—for example, 2½ miles above the gap; also below Lock No. 26, where silicious coarse quartzose limestone, with buff non-calcareous slates and a coral-bearing rock, dip 45° S. 60° E. At Etna Ironworks another sweep of the river exposes the rocks almost to the axis of the anticlinal flexure, a hollow descending into it from Canoe Mountain.

In the rolling land between the two lines of cross fracture, and N.E. and N. of the Short Mountain, there are numerous exposures of limestone, nearly vertical, but bearing almost N. and S.

Barrens.—"Barrens" extend S. to the river. The limestone dips 45° N. 35° W. along the Short Mountain. In the centre of the valley the dark, rough, grey silicious rocks appear, but exposures are few; clays and sands cover the surface, and contain much chert.

The white magnesian layers appear near the lock opposite Cove Forge, and not far off a bold cliff of the massive blue limestone exhibits the strata dipping 85° S. 75° E. Further up the river, much chert in beds abounds. The chert nodules escape and fall from the rocks, giving them a curious appearance. Blue and grey limestones, low in the Auroral series, are finely exposed at the bend of the Juniata one mile below Williamsburg; dip 45° S. 70° E.; and half a mile higher up is an exposure, 130 yards long, of alternate white cherty magnesian and blue and grey silicious and dark-blue massive limestones.

Opposite Williamsport, cherty rocks dip 60° S. 60° E. Then follow grey silicious rocks and blue limestones for 1000 yards, dipping 40° or 60° S.E. Coarse sandstone, with bluish calcareous seams, form the tall peak above Williamsburg, and dip 86° N. 40° W. Exposures, more or less silicious, continue up the river. At one place, blue limestone is followed by sandstone, with chert and oolite in the body of the rock in thin lenticular irregular layers. To this succeeds a dark olive and grey rough sandstone, mostly twisted and crushed, but normally in vertical posture, full of veins, and weathering in holes and ridges; some parts of it are calcareous. Then follows a dull greenish olive slate with seams of quartz, white and curled. This is one mile from the Short Mountain. About 300 yards further on occurs a change of dip to 12° N.W., then 45° N. 30° W. Exposures are abundant to the foot of Short Mountain, where occurs the passage into slate.

Morrison's Cove.—S.W. of the Juniata we enter upon the so-called Morrison's Cove. The valley becomes wider, continues anticlinal and regular. It has a line of cultivated land along each margin, and is occupied through the centre by extensive and elevated sandy barrens. Clover Creek drains its W. and Piney Creek its E. side, and the rocks are frequently exposed along them. The little anticlinal flexure, before described as issuing from a shallow cove in Tussey Mountain, is seen upon the Clover Creek near Mr G. Smith's house, where the dip of 55° S. 70° E. of the main anticlinal, gives place to a gentle N.W. dip, followed by horizontal stratification, and this by steep S.E. dips as before. At Spar's Sawmill, dips of 15° to 40° toward N. 30° E. are seen belonging to this small flexure, which is here rapidly subsiding. At the fulling-mill the dip is 35° S. 70° E. Between Biddle's and Ditche's mills the dips are all about 40° S. 65° E.

Proceeding S.W., the farming land narrows: the Barrens approach the mountain, so as only to leave a hollow for the creek, as at Rebecca Furnace. Further on, denudation has acted less, and the land rises. At the furnace, the dark-blue limestone, containing fossils, and the magnesian middle beds, are exposed.

A very remarkable rock is exposed 3½ miles S.W. of the furnace, and 1½ from Tussey Mountain. It is a thin grey-and-red flagstone, splitting readily into regular smooth plates, some of them even 10 feet square, and sometimes not half an inch thick. It dips 40° S. 60° E.

From the mouth of Piney Creek to Springfield Furnace the surface is very irregular, and the stream flows in a deep winding dell. The dips are uniformly 60° or 70° N. 55° W. Beyond the furnace the land is more even. The cultivated tract narrows between the end of Lock Mountain and the Barrens. As the land rises, the head-waters of Piney Creek flow through a flat and unbroken surface, covered with clays, sands, and fragments of chert. To the S.W. of Martin's Bay, which lies in the synclinal of Lock Mountain, the whole district is an elevated table-land; it has some fine farms, but the greater part consists of barren rolling lands.

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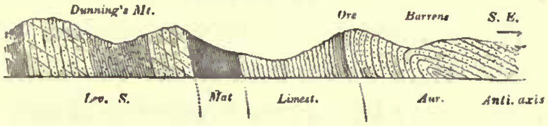
INDIAN CHIEF-ROCK, NEAR WILLIAMSBURG, JUNIATA RIVER.

CHAPTER XIV.

MORRISON'S COVE, OR CANOE VALLEY PROLONGED.

An anticlinal axis which rises near Frankstown, and forms the angle and spur where Lock and Dunning mountains join, lifts the Auroral series in a wide limestone region called Morrison's Cove and Snake Spring Valley. The normal form of this great flexure is exhibited by the vertical dips in the gaps in Dunning Mountain, near the angle, while all the S.E. dips are very gentle. In the broken country near M^cKey's Gap there are many exhibitions of the white magnesian and grey silicious members of the lower part of the formation, and of the purer blue and fossiliferous layers of the uppermost, along the streams that issue by the gap. The dips are usually from 15° to 35° E., and on the N.W. side of the axis are vertical. Near Maria Forge there are fine exposures along Roaring Spring Run. There is a narrow strip of cultivated land along Dunning's Mountain, but S.E. of Maria Forge the surface is undulating, and pretty good for farming. Along the anticlinal axis, however, extend the Barrens, rising into a ridge which in places is nearly as high to appearance as Dunning's Mountain.

Fig. 98.—Section of Dunning's Mountain, and High Barrens, Morrison's Cove.



This ridge slopes as a barren undulating synclinal plain, covered with scrub oak and pitch-pine. The range of barren hills becomes lower and flatter towards the S.W. end of the cove, but is still covered with sand and clay, loaded with flint, quartz, and fragments of the lower silicious limestone beds of the Auroral series. Yellow Creek affords numerous exposures of these lower rocks, dipping gently one way, and vertically the other. The cultivated land becomes much wider opposite the Buckstown fold of the mountain.

The anticlinal axis, which produces the cove behind the angle at Buckstown, is not expressed satisfactorily in any exposures of the strata. The denuding forces have acted with great energy, and swept away the Matinal slates. The dip in general varies from 25° to 40° S. 60° W. The vertical dips along Dunning's Mountain continue to within a short distance of its deflection South-eastward, where the superior height of its summit indicates a gentler dip, and a consequent greater resistance to denudation.

The whole area W. of the anticlinal, between Lock Mountain and the loop of Tussey Mountain, is an undulating open country, mostly uncultivated, but with occasional arable spots of "limestone clay"—so called by the farmers. Seen from above, it looks like a vast plain covered with pine forest.

CHAPTER XV.

SNAKE SPRING VALLEY AND FRIEND'S COVE.

1*st Axis.*—The Morrison's Cove anticlinal flexure flattens S.W., so as to allow a broken arch of Levant grey sandstone to spring across from the terrace of Dunning's to the terrace of Tussey's mountain, and separate the cove from its geological continuation, Snake Spring Valley. The limestone begins to appear upon the axis 2 miles from the head of the valley, the surface of which is covered with fragments of chert and Levant sandstone. The drainage is along its S. side, where Tussey's Run flows, fed by transverse runs from the N.W. mountain-slope. About $1\frac{1}{2}$ miles from the river, some hills rise in the middle of the valley, and continue as a high range through its S. end, called Friend's Cove. East of the turnpike, 2 miles, the dip is 80° N. 50° W.; the S.E. dip is much gentler. Further W. they are respectively vertical, and 40° S.E.

2*d Axis.*—The traverse of the river exposes the limestone dipping from *two* anticlinals. The dips are first nearly vertical in Tussey's Mountain; then generally 30° or 50° S. 50° E.; then 45° N.W., and immediately 75° and 40° S.E.; and, lastly, vertical, and twisted into Cove Mountain. Here we see both of the two anticlinal flexures which traverse Friend's Cove, and issue respectively by its two S. corners, closely compressed in its overturned N.W. sides. They are clearly demonstrable only toward the S. end of the valley. Around the S. end of the central barren high-land of the valley, the fertile strips meet in a common plain. The central range is double at the river. The dips S.W. of the river, along the base of Cove Mountain, are overturned to 60° S.E. But $3\frac{1}{2}$ miles from the S. end of the cove, exposures give 30° N. 60° W., the usual inclination being 50° or 65° N.W., and 25° S. 50° E. Cove Creek, at Betz's Mill, exposes the argillaceous layers dipping 35° N. 70° W. Neighbouring rocks full of fossils dip 25° S. 50° E.

Cove Creek drains Friend's Cove along the outcrop of the upper Auroral limestone on its S. side. It nowhere exposes Matinal slates. The dip is usually 40° S.E. The broad table of barrens, on the W. side of the narrow vale of the creek, is covered sometimes with enormous masses of black chert, weighing several tons, full of white veins and cavities, and filled with sand or empty, with crystalline inner surfaces. About 7 miles from the river, the vale opens out into the beautiful level farming region of Rainsburg, at the head of the valley or cove. The exposures W. and S.W. of Rainsburg exhibit a synclinal structure. The N.W. anticlinal runs into the angular nook on that side, and the S.E. anticlinal into the semicircular bay on the other side. Both anticlinals decline, and cease to bring up Matinal rocks, but produce two long slightly diverging mountains, which enclose Bean's Cove.

By glancing at the Map, the mountain through which the Juniata enters the cove is seen to be flexed to the N. and S. of the gap. At each flexure there is a transverse fault, beyond which, on each side, the rocks dip about 40° or 45° N.W., but the whole piece between is thrust forward, and up-thrown towards the N.W. Its rocks are seen along the river, standing vertically, and greatly contorted where the greatest slipping took place, or in the upper Matinal slates.

A reference to the Map will spare tedious and unsatisfactory explanation of the topography between Friend's and Bean's coves—which at first sight would seem to be as continuous, and for the same reason, as Morrison's Cove and Snake Spring Valley. But Bean's Cove, next to be described, is a synclinal valley, and contains higher rocks than those of the Matinal series.

CHAPTER XVI.

BEAN'S COVE.

Anticlinal Axis.—Evit's Mountain, which bounds Bean's Cove on the W., being anticlinal, and terminating a few miles beyond the Maryland line, has a double summit, of the Levant white sandstone formation, the E. crest being, however, higher and more regular than the other, which is cut deeply by a series of ravines. So the whole, when viewed from the W., bears a striking but deceitful resemblance to a mountain of the Levant sandstone, with its terrace bounding an anticlinal valley of Auroral or Matinal rocks. The cause is, as usual, a difference of inclination in the strata, the W. being vertical or overturned, the E. dipping 40° or 60°. A good section of the mountain is obtained in a gap near the Maryland line.

Within the head of Bean's Cove, and on the flank of Evit's Mountain, there is a ridge of white sandstone gradually losing itself in the mountain, and probably due to a small sharp anticlinal flexure.

Anticlinal Axis.—Another anticlinal enters the head of Bean's Cove in a long spur. Tussey's Mountain, on its E. side, is at first very broad and anticlinal; its dips are 45° S. 40° E., and 50° N. 25° W. It also comes to an end beyond the Maryland State line, but previously seems to include and throw out in a spur a sub-flexure on the right. Flintstone Creek makes a section of it S. of the State line, exposing rocks that dip 15° or 25° both ways.

At the head of Bean's Cove are naked pavements of Levant white sandstone, scarcely visibly inclined to the horizon. Upon these pavements rise the Surgent slates and shales. In the middle of Bean's Cove rises a range of hills called Martin Mountain and Flintstone Ridge, and composed of the Scalent and Pre-meridian limestones, capped by Meridian sandstone. Approaching the State line, they are nearly as high as Evit's Mountain. Between it and the boundary mountains of the cove are two long narrow vales of Surgent shale. At the State line, and for 3 miles N., the district between Evit's Mountain and Martin Hill is a barren tract, the poor clay soil of which is full of fragments of Levant sandstone, overgrown with dwarf oaks and pines. This superficial detritus covers up all the Surgent and Scalent shales and marls. About 5 miles from the line, the slates dip 30° S. 60° E., and 35° where the road crosses Evit's Mountain. Two distinct low ranges of hills are traceable, composed of the red and white silicious strata. The fossiliferous ore could not be found in place, and but a few small surface fragments were seen. N.E. of Martin Hill the shales spread out, exhibiting in one place a small flexure or wrinkle, parallel with the major anticlinals, and very gentle.

The small anticlinal descending from the head of Bean's Cove does not seem to affect the Surgent shales to any great extent. On the E. side of Martin Hill, surface specimens of the fossiliferous ore were picked up near Mr Dicken's house. The dip, half a mile N.E. of the spot, at Mr Hamilton's, is 40° N. 60° W., where surface fragments were also found in the S.E. slope of the low ridge of white Levant sandstone.

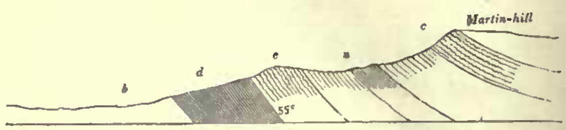


FIG. 99.—Section of Martin's Hill, Bean's Cove.

Flintstone Creek exposes the Scalent and Pre-meridian limestones. Thus 3 miles from the line we have the following section :—

At *b* a deep narrow hollow, steep on both sides ; at *a* numerous sink-holes, and surface covered with fragments of sandstone and chert ; at *c c*, limestone ; at *d*, red shale.

Opposite Wigfield's Mill, one mile from the line, a section reads thus :—Yellow slate ; above it, ferruginous calcareous bed, a few inches thick ; then calcareous seams with slate ; thin slates ; impure fossiliferous *ore-seam* 8 *inches thick ;* massive sandstone 3 or 4 inches ; olive slate 8 feet ; rough, grey, massive sandstones ; ash-coloured slates.

Nearly half a mile from the line this would be the section : Light buff slate for 60 yards, dip 30° N. 60° W. ; above them bluish, yellow, and ash-coloured slate ; light brownish yellow slate ; loose ferruginous sandstone ; fossiliferous ore in fragments ; white sandstone ; yellow slate ; red sandstone and shale, &c. The weathered surface-specimens of ore in the region are of excellent quality.

CHAPTER XVII.

WILLS' MOUNTAIN AND MILLIKEN'S COVE.

WILLS' MOUNTAIN anticlinal flexure terminates N. of Bedford, and runs S.W. into Maryland, lifting, within the cloven walls of the mountain, the long, slender, canoe-shaped valley of Milliken's Cove.

Two small adjunct flexures add two small spurs to the mountain's N.E. end, and spread its summit. The Easternmost of these has its rocks dipping 50° S. 70° E., and 35° or 45° N. 60° W., as seen in the ravines that descend upon Bedford. The Westernmost is the main anticlinal, with gentle S.E. and steep N.W. dips. This continues to be the relation of its sides far to the S.W. While the verticality of the rocks of Buffalo Mountain (the W. ridge) has exposed it to enormous degradation, the gentleness of the dips in Wills' Mountain (the E.) has left its crest high and regular. The inner terrace is in some places swept away, but in others it is high and well marked. Beyond, where the walls reunite, a long, slender, and nearly parallel spur parts from the mountain. It is composed of crushed and folded rocks, and is doubtless due to some small but sharply-collapsed anticlinal flexure, issuing, as it were, from the main one.

The principal part of Milliken's Cove consists of outcropping Matinal slates, ploughed by denuding waters in directions towards the gaps in Buffalo Mountain, and dipping 30° or 40° S. 60° E., and 70° N. 60° W. The formation must be of considerable thickness. In its lower members there are many fossils, and springs rise from its slates impregnated with sulphurated hydrogen. One of these is the well-known "White Sulphur Spring," near the Sulphur Spring Gap.

The Matinal limestone is exposed but at three places along the anticlinal: one of these is at Andrew Miller's, near Swigert's Gap, where the highest layers of the formation crop out vertically; another is half a mile to the N.E., where but few of the dark argillaceous layers are exposed with the Matinal slates, which are themselves frequently calcareous. The limestone beds might be uncovered in many places, by the removal of the superficial deposit of clay and sand.

DIVISION IV.

FOURTH BELT OF THE SIXTH DISTRICT, OR STONE, HARE, WOODCOCK, AND TROUGH-CREEK VALLEYS, AND BROAD-TOP MOUNTAIN.

CHAPTER I.

STONE VALLEY.

THE general synclinal flexure already described as having its axis along the Wyoming coal-basin, issuing at the Knob or Shickshinny Mountain, and as traversing the longest diameter of Buffalo Valley to the point where it closes up between White Mountain and Paddy Mountain, may be traced through the Seven Mountains along Stone Valley and the Broad-Top Mountain into Maryland.

It is shallowest and narrowest at the Seven Mountains, where it contains no formations higher than those of the Levant and Surgent series; but it deepens and widens E. and W. in Buffalo Valley and Stone Valley respectively, and receives the Pre-meridian, Meridian, Cadent, Vergent, and Ponent series, and in the Wyoming Valley and the Broad-Top plateau, the Ponent, Vespertine, and Coal rocks.

Neglecting for the present the region of the Seven Mountains, we will describe the counterpart to the Buffalo Valley, the valley of the Standing Stone.*

It embraces a triangular district of Levant, Pre-meridian, Meridian, Vergent, and Cadent rocks, bounded on the S. side by the gently-curving summit of the Stone Mountain, and on the N. side by a series of ridges, backed by Tussey's Mountain, forming a series of anticlinal flexures arranged in echelon, very similar to those of the Buffalo Mountain, described in the last Chapter, but of much smaller size. We may regard the valley as still widening S.W. of the Juniata, but bisected by the great synclinal mountain of the Vespertine series called Terrace Knob.

White Stone Valley is a synclinal trough, encircled at its borders by the outcropping strata of the Levant and Surgent series, and filled in its central portions with the higher groups; it is traversed by many such ordinate and parallel anticlinal flexures issuing from the Seven Mountains, and by some that originate in the valley itself. The first part of our description, therefore, will relate to the position, direction, and general character of these secondary flexures, taking them in succession from S. to N., and tracing each from E. to W.

* Huntingdon, according to tradition, was called by the first settlers "Standing Stone," from a rude stone pillar, 15 or 20 feet high, that was then erect near the Juniata, at the spot where the Indian tribes held their grand councils.

1. *Synclinal Trough of Milliken's Knob in Kishacoquillas Valley.*—Stone Mountain forms the S. side of this crest, the axis of which runs from the knob S.W. through the narrow valley lying at the N.W. foot of Stone Mountain, and through the limestone knob at the junction of Rocky Ridge and Warrior Ridge, 16 miles E. of Huntingdon, and thence through the Cadent and Vergent hills and along the Ponent red sandstone tract, 3 miles E. of the river, where it enters the Terrace Knob. It next traverses Trough Creek Valley, goes through Shirley's Knob and Rocky Ridge until it is lost in the Broad Top Mountain. Its Northerly dips are everywhere steeper than its Southerly ones, being from 50° to 90°.

Nearly opposite Greenwood Furnace an extensive fault traverses Stone Mountain, upon the W. side of which the rocks of the mountain are thrown forward (upward) towards the N., so that the Levant grey sandstone in the W. wall of the fracture abuts against the Levant white sandstone in the E. wall. The effects of the force here exerted are seen in striking contortions in the Surgent slates on the road leading down the mountain. The mountain runs from the fault in a direction S. 40° W., but curves gradually to S. 27° W. near Goslin-Run Gap, where another fault lets it fall off 2° more. Beyond the Juniata its range is S. 15° W.

2. *Anticlinal Axis of Broad-Top Mountain.*—This bounds the Milliken's synclinal knob upon the N. as far as the place where it enters Warrior Ridge, beyond which it cannot be traced in any one definite line.

3. *Anticlinal Axis of Stone Creek Knob.*—This knob is in the line of the axis between the third and fourth ridges of the Seven Mountains. The anticlinal is seen 40 rods N. of Mesh's house, with a N. dip of 45° and a S. of 25° E., and in Davis' Ore Hill it ranges N. of Scruple's towards Ennisville in red shale, and seems to enter Warrior Ridge like the last. Neither axis was observed with any distinctness in the section of the ridge which is made by Stony Creek.

4. *Anticlinal Axis of the S. Spur of Bear Meadow Mountain.*—The strata which occupy the broad summit of the Meadow Mountain have an unusually gentle dip, as may be seen at the notch in the S. side of its S. spur, where the inclination is not more than 17° or 20° S.S.E. Indeed, the whole plateau includes but one wide flat flexure, which, advancing W., becomes complex, and results in three sharp anticlinal waves, marked by as many mountain spurs descending into Stone Valley. This they traverse for more than 10 miles. The most S.E. axis of these may be detected at Bell's Sawmill in the ore-hill 600 yards N. of Ennisville, where it has a S. dip of 60°. Further forward it enters Warrior Ridge at a curve opposite the village.

5. *Anticlinal Axis of the Middle Spur of Bear Meadow Mountain.*—This projects beyond the last-mentioned spur, as the next one on its N.W. projects beyond it; it ends in a high hill of the Surgent slates at Steffy's Tavern. The anticlinal axis traverses this hill; its N. and S. dips are each about 40°, and opposite McMurtrie's Tavern the N. dip is 40°, and the S. is 15°. It passes into the S. side of Warrior Ridge at a similar curve to that formed by the preceding anticlinal.

6. *Anticlinal Axis of the S.W. Spur of Bear Meadow Mountain.*—This flexure is traceable through the valley into the broad limestone hill opposite Manor Hill, 2½ miles E. of McMurtrie's Tavern, and half a mile S. of a group of houses on the Bellefonte road, immediately S. of McMurtrie's house. The dips are 70° S. 35° E., and N. 35° W. It lies in limestone on Shaver's Creek south of Wilson's, but is in Surgent red shale 1½ miles E. of Petersburg; further W., after entering the rolling Meridian slate hills, it is no longer traceable.

The cut of this hill made by Laurel Run exposes the Meridian sandstone strata folded sharply twice along the top of the anticlinal flexure. The S. flexure is quite collapsed, with nearly vertical dips ; the N. flexure is regular, dipping 40° S. 50° W., and 50° N. 50° W.

7. *Anticlinal Axis of the First Spur of Tussey's Mountain.*—The great anticlinal flexure of Penn's Valley, entering Tussey's Mountain on its W. side, behind the high knob or offset opposite Boalsburg, does not pass through the mountain, but is represented on the S. side by a succession of small flexures, the first or most Eastern of which is small and low, running out next and parallel to the most Northern spur of the Bear Meadow Mountain.

The Geological Map indicates the position of these spurs projecting W. They show in a striking manner how the topography is related to the geological structure.

According to a very general law visible in other parts of the Appalachian Chain—for example, in the Wyoming and Shamokin coal-basin—the numerous lesser flexures run into the curved side of a principal flexure. This curious obliquity, so perplexing in some collieries, is the result of a species of warping or wrinkling of the upper strata, from the interference of converging or opposing larger flexures of the earth's crust. A bird's-eye view of these six ridges may be obtained from the most Northern spur of the Bear Meadow Mountain.

This little anticlinal ranges through Mars Hill, and is crossed by the road from Steffy's to Pine Grove. Its N. and S. dips are 20°. Before reaching Rudy's, the North-dipping Meridian sandstone shows that the flexure no longer exists in that direction.

8. *Anticlinal Axis of the Second Double Spur of Tussey's Mountain.*—This axis forms a double ridge, the S. summit of which is the higher of the two. Each, in fact, contains a flexure. The axis runs through a hill of Meridian sandstone N. of Rudy's, and thence through Leightner's land S. of McMahan's, where it causes the Surgent red shale to dip both ways 45° or 50° respectively. Further W. it is observable in higher strata at McMurtrie's. The other flexure is not traceable for any distance.

9. *Anticlinal Axis of the Third Spur of Tussey's Mountain.*—This terminates as a ridge near Maffit's, on the Bellefonte road, but is not traceable as a flexure further W.

10. *Anticlinal Axis of the Fourth Spur of Tussey's Mountain.*—This forms the largest of the six ridges. It blends W. with the next on Stony Ridge—or Leading Ridge, as some call it—into the S. flank of which it seems to run, and soon to expire.

11. *Anticlinal Axis of the Fifth Spur of Tussey's Mountain, or Stony Ridge.*—This flexure dies out in Surgent shales at the Little Juniata River, and along its summit Levant white sandstone was observed dipping 15° N. 30° W., and S. 30° E.

12. *Anticlinal Axis of the Sixth Spur of Tussey's Mountain, or Pine Ridge.*—This flexure elevates Pine or Round Top Ridge, which ends in a bluff one mile E. of Dorsey's Forge, and contorts the limestone exposed on the river below the forge, to the W. of which it soon expires.

Tussey's Mountain west of Pine Ridge contains Levant sandstones, dipping S.E. from the great anticlinal of Nittany Valley. A great dislocation undoubtedly exists at the gap of the Little Juniata, for here the mountain, which has made a gentle curve from Boalsburg, and approaches the river with a course S. 60° W., and with a moderate dip, exhibits, after passing the river, only vertical dips, and runs almost due S. to the next gap, or that of the main Juniata. There it again falls off to S. 20° W. Still further forward it recurves and folds within its loop a long cove or valley leading W., but, bending abruptly back towards the S.W., it forms a bold anticlinal knob, conspicuous from every part of Stone Valley.

Warrior Ridge.—The Warrior Ridge, which occupies the centre of Stone Valley, is but the outspreading of its Pre-meridian, Meridian, Cadent, and Vergent strata, upon the ends of the first anticlinals of the above-described series. Rocky Ridge is the continuation of Warrior Ridge along the S.E. side of the grand axis of the synclinal basin.

Having thus described the structural geology of the district, we will take up the formations in the ascending order—which is the order of time—and trace their respective outcrops.

1. *Levant White Sandstone of Tussey's, and Stone, &c. Mountains, Surgent Slates, and Ore Shales, at the Base of the Mountains.*—The Levant white-sandstone formation constitutes Stone and Jack's mountains, the knobs of the Seven Mountains, and Bear Meadow and Tussey's mountains. In the gap of Jack's Mountain the anticlinal axis of Kishacoquillas crosses the Juniata, the grey, red, and white sandstones arching gently over the Matinal slates at the water-level. Toward the N. end of the gap, however, the N. dips of the anticlinal become nearly vertical, and continue to be very steep as we ascend the river through the various formations. The red shales are seen dipping 75° N. 70° W., and the Meridian sandstones of Rocky Ridge are slightly *overturned.*

This steepness of N. dip continues for 18 miles along Stone Mountain N.E., and is the reason why the Surgent ore-sandstone forms no separate distinct ridge at its base, as it elsewhere does wherever a gentle dip removes it further from the mountain, and spreads its outcrop to resist denuding action.

About 18 miles N.E. of the Juniata the Surgent shales pass up into the synclinal trough between Broad Mountain and Stone Mountain, running in by Greenwood Furnace. They then lap round the Broad Mountain on the ore-side, forming an elliptical chain of ore-hills, on which are, or were, Alexander's and Diarmid's ore-openings. Folding round the limestone knobs which terminate the Warrior Ridge upon the other side, they spread broadly over the anticlinal flexures at the foot of Tussey's Mountain, and extend down Shaver's, Hartzlog, and Woodcock valleys.

The Surgent Red Shale in all this course has much more of a silicious than argillaceous type. The Surgent calcareous ore-shales often display pure limestone beds, but usually these are too argillaceous for the kiln. They may be studied well at Roberts's, and between that and Shaver's Creek, as well as on the creek opposite Wilson's. The Surgent ore-sandstone is thinner than in the Lewistown Valley, but is an equally good key to the other members of the group.

A remarkable locality of ore is that upon the flank and near the summit of Stone Mountain, at Goslin Run Gap, at the head of a ravine which runs S. from the jaws of the notch.

The ore was dug at first in sandy clay, but as the depth increased, it became apparently a rather ferruginous stratum of sandstone, but of very inferior quality as an ore. If this occurs in the Surgent lower slates, it may be the equivalent of the Bittenbender ore of Montour Ridge, described in the chapter on that district.

Detached masses of ore of great size and weight have been found upon the spurs at the head of Stone Valley, and may be referred to the same range of ferruginous sandstone, or be considered debris from a distance.

The Surgent slate group consists of olive and buff slates and shales that become of a deep yellow in the upper part of the formation. Over these lies a compact white or yellowish greyish-white sandstone, breaking into rhomboidal masses, and characterised by its fossils, the more abundant of which are joints of encrinites. It is thinner, softer, and more calcareous here than in the Lewistown Valley, covering the hill-sides with loose fragments of a rotten aspect, and dirty buff colour. Judging from the distribution of these fragments compared with those of the fossiliferous ore, the former overlies the latter. But at Dorsey and Green's ore-banks, $1\frac{1}{2}$ miles S.W. of the forge, the sandstone underlies the ore. This is sufficient evidence of the existence of more than one ore-stratum.

Previous to the examination of the region by the Survey, the following practical tracing of the ore had been accomplished.

Dr Dorsey had made excavations along the base of Jack's Stone Mountain, but, owing to the vertical position of the beds, he found the ore valueless from insufficient thickness. On the canal it proved to be but 4 inches thick, dip 75°; distance below the bottom of the red shale, 225 feet.

Messrs Alexander and Diarmid had opened shafts on the broad summit of the hill that arches over the anticlinal axis, and around the foot of the Broad Mountain, but in the Surgent upper slates. At a lower level on a road an ore-bed crops out, which was stated to us to be $2\frac{1}{2}$ feet thick, and to dip W.; but not far off where it was covered with shale and soil, it was said to be but 20 inches thick. It was said to be good soft non-calcareous ore, of a rich purple colour.

Messrs Dorsey and Green's principal openings were on a small hill parallel to Tussey's Mountain, and half a mile N.E. of the forge. An ore stratum here dips 25° S. 40° E., and is 18 inches thick: it is hard and calcareous, lies in slabs of square or rhomboid form, and yielded on analysis 39.90 per cent of iron. Beneath it lies the Surgent olive shale, and above it the encrinitic and massive hard slightly-calcareous Ore-sandstone. The position and hardness of this ore make it somewhat difficult to mine.

On the same ridge, between the Little Juniata and the Pennsylvania Canal, other openings displayed a stratum of rather different character, and under it the encrinitic Ore-sandstone. Analysis showed iron 32.20 per cent. The dip is here steep, and the crest of the ridge narrow.

The outcrop of the bed of iron ore must follow the sinuosities of the base of the mountain from Alexander and Diarmid's openings, and curve around the three spurs of the Bear Meadow Mountain, but it cannot be everywhere traced as a *ridge.* A single hill at Davis's, W. of Marsh's, covered with the fragments of the Ore-sandstone, marks the line around the Stone Creek Ridge, but no ore was discovered.

An ore-ridge follows the foot of the first spur of the Bear Meadow Mountain south of Bell's Sawmill. Its dip is 60° S.; it runs one-third of a mile N. of Ennisville, and immediately N. of Saltzburg, and ceases 2 miles E. of Manor Hill. The dip is everywhere S.; the surface specimens of ore are not abundant. Just at its termination it is an anticlinal ridge, but there is no corresponding North-dipping ridge of it.

The two outcrops belonging to the next spur are not marked by ridges. One or two isolated hills only, occur 3 or 4 miles S.W. of Steffy's. Opposite Manor Hill an anticlinal hill is seen, covered with the fragments of the Ore-sandstone, but the presence of the ore is doubtful. Dip 40° S.

The S. outcrop of the next flexure, that of the third spur, runs along a ridge 1 mile N. of Steffy's Tavern. Specimens of a yellow ore, deep purple when bruised, of fair quality, but of thickness unknown, containing large fossil-shells, are numerous on the surface. The ridge extends $1\frac{1}{2}$ miles to Blair's and Starr's, where the ore is abundant. The N. outcrop of the same flexure is in a ridge S. of Rudy's farm. The two unite, and extend as an anticlinal hill, passing 50 yards S. of McMurtrie's Tavern, where the Ore-sandstone is seen, but the ore stratum itself has gone below the surface 1 or 2 miles E. of that tavern.

The next ore-ridge, containing an anticlinal outcrop, passes to the N. of Rudy's Farm; it runs by Wm. Johnson's house, and continues to McMahan's, $2\frac{1}{2}$ miles E. of McMurtrie's Tavern. The two outcrops separate Eastward at the road leading E. to Pine Grove, the N. one passing Leightner's farm, where its ridge declines, the S. one running to the N. of James Leonard's.

The zigzag outcrop runs next by Maffit's. The ridge to the E. of the Bellefonte road is covered with specimens of good ore. Westward it passes through More's land, N. of whose house lie many surface specimens; thence along the foot of Stony or Leading Ridge through Roberts's land, where it is joined by a North-dipping outcrop ore-hill, which issues from behind Stony Ridge, and both run on upon the anticlinal axis together to the Juniata River, where they are covered with fragments of the Ore-sandstone.

No distinct hills follow the next pair of outcrops around Round Knob or Pine Ridge, but a broad flat plain spreads to the W. of it, in which the ore is seen to dip gently.

The last outcrop forms a very distinct ridge along the foot of Tussey's Mountain, crossing the Little Juniata at the forge, and the Pennsylvania Canal one mile W. of Alexandria. It continues with interruptions through Hartzlog Valley, and some distance along Woodcock Valley, passing by Governor Porter's farm, after which its dip increases, and it coalesces with the mountain-slope.

This is the course of the outcrop of the Surgent fossiliferous ore. There is, however, another ore in this series, which has been fully described in the Lewistown Valley, but which is only rarely observed in Stone Valley. This is the ore found on McCahan's land at the foot of Stone Mountain, a few miles N.E. of Goslin-Run Gap, and on Corbin's land, at the opening of Hare's Valley south of the Juniata. It is of good quality, but did not promise an abundant yield.

Scalent Marls.—While the Surgent ore-shales are confined to a single ridge running along the foot of the little anticlinal mountains, and of Tussey's Mountain itself, there is a succession of other parallel anticlinal ridges consisting of the Scalent marl group occupying the surface of Shaver's Valley for 3 miles in breadth, along the Juniata River down to Petersburg. These gentle rolls are but the continuation of the flexures that issue from the spurs of the Bear Meadow Mountain, and the flank of Tussey's Mountain further E., elevating first the ore-shales, then the red shale, and finally the green and yellow marls, in gently rolling hills of the greatest fertility. These extend S.W. of the river for 15 miles until the flexures that bring them up themselves die out. About 2 miles S.W. of Garner's farm the last flexure disappears, and but one dip is seen from Tussey's to Terrace Mountain.

Scalent Limestone of Stone Valley.—This formation consists here, as elsewhere, of alternate dark argillaceous and calcareous shales, the latter frequently massive, and fit for the limekiln. They graduate downward into the Scalent marl group, and pass upward into hard and pure limestone covered by the coarser Pre-meridian calcareous cherty rock.

Fine exposures may be studied where the Juniata breaks through Warrior and Rocky ridges. A large quarry 2 miles from Petersburg shows 10 feet of the strata, which are rather of a laminated structure in the lower part. The middle, 20 or 30 feet, consists of massive solid beds of dark-blue limestone, of fine grain and conchoidal fracture: the higher layers are of a pale-blue colour, very finely grained, with a smooth fracture. Above all are grey and mottled beds, admitting a good polish, breaking irregularly, and full of beautiful calcareous spar.

These rocks compose many of the hills in Shaver's Creek, Hartzlog and Woodcock valleys. Among them is found an ash-coloured very argillaceous limestone, wholly unfit for burning or building: solid enough when quarried, it crumbles down upon exposure to the air, and will deceive the expectations of those who use it. It is finely exposed 300 yards below the forge at Petersburg, where it is interstratified with black slate and some better limestones.

The outcrop of the Scalent and Pre-meridian limestone strata is traceable in a ridge running parallel with Rocky Ridge, and distant from it 200 to 300 yards. It sweeps round the junction of Rocky Ridge, and with Warrior Ridge on the E., forms the two other knobs or spurs, and most of the body of the latter; to the S.W. it appears in long anticlinal belts, with synclinal Meridian sandstone between it; confines itself at length, with steepened dips, to the N.W. border of the valley, and, with an average breadth of about one mile, crosses the Juniata, and forms at M^cConnellstown the Westernmost of the two hills with which the singular platform of Warrior Ridge terminates in that direction.

In the section made by Stone Creek, the limestone shows itself opposite to Couch's Forge, and thence to Ennisville. Its whole breadth of outcrop is thus displayed. Silicious limestone beds underlie a farm opposite Foster's, upon the ridge, the ascent to which, at a high bluff, exhibits a dip of 15° N.W. To the N. of it lies the "barren ground," from which at intervals rise limestone knolls, until within half a mile of Price's, where a high ridge shows a dip of 30° N. 40° W., and from this down into Shaver's Valley all is limestone. At Price's house, silicious Pre-meridian limestone beds dip 15° S.E.

Sink-holes are found in the "barren ground" along belts of limestone, where the traveller would suppose all was a sandstone plateau. To the S.W. a few scattered sink-holes on the ridge are the only evidence of the presence of limestone, and of course these must occur chiefly along the anticlinal flexures. On the road from Warm Springs to Petersburg no limestone is visible; horizontal Meridian sandstone strata alone appear to form the Warrior Ridge until within one mile of Shaver's Valley. Limestone appears upon the Juniata as far down as the lock, simply because the river has cut so deep a trench in the ridge as to reveal it below the undulating line of its contact with the overlying rocks. The limestone caps those eminences only which rise to the W. of the aqueduct, which is half a mile below the forge near Petersburg.

Iron Ore.—Mr Diarmid had, at the period of our investigations, sunk a shaft through sand, clay, and sandy ore, upon Warrior Ridge, in connection with the limestone outcrop. Not far from Couch's Forge, on the road to Ennisville, an abundance of small fragments of ore strews the soil of Warrior Ridge, but shafts have revealed none in place. At Diarmid's Shaft, fine white clay is covered with sand, evidently owing its origin to the decomposition of the Meridian sandstone rocks of the ridge. Of these we now proceed to speak.

Meridian Sandstone.—This is a coarse-grained rock with a crystalline surface; it is massive, is traversed with regular and numerous rectangular joints transverse to the dip, and crumbles, on exposure, into sand, leaving the original masses between the joints roundish; it has two great outcrops in Stone Valley.

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STONE RIDGE, NEAR JACKS NARROWS, JUNIATA RIVER.

The more Southern outcrop issues from Hare's Valley as a series of round hills, reminding one of the separate joints of a vertebral column; it crosses the Juniata opposite the gap at Drake's Ferry, exhibits there vertical dips, and follows the Stone Mountain until it unites with the S. slope and E. end of Warrior Ridge. Along this line, Rocky Ridge exhibits ragged mural precipices upon its N. side, destitute of all vegetation, and built of the massive, cleft, and easily-degraded vertical strata of the sandstone. (See the Sketch.)

The N. outcrop may be said to be in general Warrior Ridge. This plateau is about $2\frac{1}{4}$ miles wide opposite Ennisville, where it is cut through by Stone Creek Exposures are, however, few, and the strata greatly contorted by the flexures from the Seven Mountains. The sandstone dips 10° S. on the right of the road as we enter the gorge from the S. Opposite Couch's Forge the limestone dips 15° S., and three-quarters of a mile further N. it dips 45° N. 40° W. We have thus an anticlinal (perhaps there are several) between the two exposures.

In the large quarry half a mile from Ennisville the inclination is again S., 75° S. 55° E., and beyond that to where we issue upon Shaver's Valley the dips are much confused. Eastward, the flat top of the ridge runs out into two limestone spurs along the synclinal troughs produced by the anticlinal seen in the gorge of Stone Creek, and a third synclinal sandstone spur or point occurs where it unites with Rocky Ridge. (See the Map.)

The S. brow of the Warrior Ridge plateau bears S. 63° W. to Couch's Forge, thence S. 58° W. to Foster's, then S. 54° W. to the Warm Springs, thence gradually becoming S. 35° W. to where it crosses the Juniata.

The N. bears from Ennisville S. 75° W. to a point $2\frac{1}{2}$ miles S.W. of Manor Hill, where two curves occur, as mentioned in describing the course of the two Bear Meadow Mountain spurs; thence to Petersburg, S. 40° W., opposite which the breadth of the ridge is perhaps 4 miles, caused by a succession of gentle rolls. At M^cConnellstown the plateau has so narrowed by the disappearance of these rolls, that but two narrow ridges remain, one of which ends in a point, the other runs on as a line of hills, with S. dips, through Woodcock Valley, and corresponds exactly to Stony Ridge, bearing the same relation to Terrace Mountain that the latter does to Stone Mountain.

While the vertical outcrop of Meridian sandstone in Rocky Ridge is but 2 miles S. of the axis-line of the synclinal trough running through Terrace Knob, the gently-dipping outcrop at Warrior Ridge is thrown off to a distance of 4 miles to the N. of the same. Here the dip S. is but 5°. Opposite Warm Springs the dip at the foot of the slope is 20°, but decreases as we ascend over the successive step-like outcrops of the sandstone layers, to the summit, where the inclination is but 7°. Now, as the Rocky Ridge bending E. diminishes the steepness of its dips, the Warrior Ridge, curving in the same direction to meet the other, shows its dips always increasing in steepness, and thus the synclinal trough becomes more symmetrical.

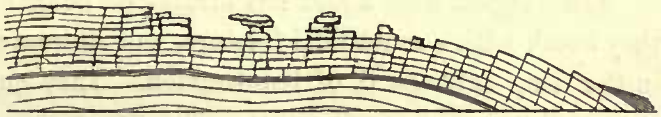

FIG. 100.—Section of the Warrior Ridge at the Pulpit Rocks.

Where the nearly horizontal outcrop of the Meridian sandstone forms the walls of the gorge of the Juniata through Warrior Ridge, it is fissured and weathered in remarkable shapes, generally thrown into a range of buttresses, advancing at a right angle upon the river.

But upon the upper plateau of the Warrior Ridge the traveller will see piles of blocks, called the Pulpit Rocks, remnants of the once more widely outspread upper strata, reared in rude columns one upon another. A correct sketch of a group of these is represented in the Frontispiece to this volume. The mode of their formation is suggested by the accompanying diagram. In all the ravines or gorges where the strata are inclined, they exhibit bluffs of characteristic aspect, often 30, 40, or 70 feet in height, such as are represented in the annexed drawing at *a*. The other, *b*, is meant to show one of these bluffs 20 feet in height.

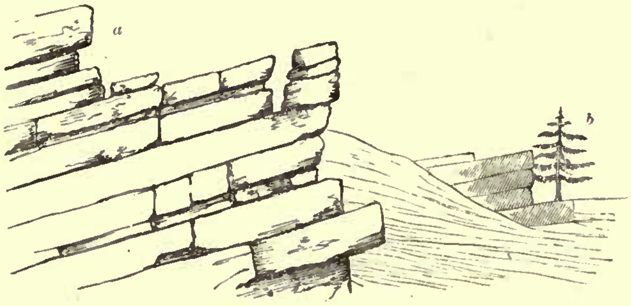

FIG. 101.—Pulpit Rocks.

When at a steep angle, the outcropping strata show another form. They rise in a series of blocks, the edges of which are all rounded by weathering.

Some of the layers are close-grained and more compact than others, splitting into larger and more regular masses, less intersected by cracks, and answering better for hearthstones for iron-furnaces, for which, when well selected, they are sufficiently durable.

In the lower part of the formation are some light buff-coloured highly-argillaceous beautifully-striated strata, perhaps peculiar to this district. They contain a few fossils, and may be studied on the Huntingdon and Hollidaysburg Turnpike west of the Pulpit Rocks, where they are used for the road ; and on the bank of the canal, in the gap of Rocky Ridge, where they are curiously fissured.

The whole thickness of the Meridian sandstone formation here must be over 100 feet.

Cadent Series in Stone Valley.—The Cadent black slates, cement layers, and grey and blue sandstone strata, are exposed along the Juniata near Huntingdon.

The cement layers, so-called, yield no cement-stone in this region, nor are they as fossiliferous as on the Susquehanna. They range along the S.E. base of Warrior Ridge, and N.W. base of Rocky Ridge. They were burnt for lime at Foster's, 2 miles E. of Warm Springs, exhibiting themselves in long rhomboidal blocks, with layers of black argillaceous limestone alternating with dark-blue massive fossiliferous strata seamed with spar, and they are fetid and pyritous. At Mill Creek Furnace, blue argillaceous limestone, full of fossils, was thrown out of a well. When first quarried, it was solid, but crumbled in the air. On the opposite side of the river are layers of blue calcareous argillaceous sandstone, alternating with blue and grey slate, and effervescing briskly in an acid. They dip nearly 90°.

These probably lie higher in the series than the cement layers before mentioned.

The Vergent flags above the strata last described are blue or bluish-grey, and fine-grained ; they break with a conchoidal fracture, and alternate with blue and olive slates, and crop out finely in the deep cuttings S. of Huntingdon. They constitute a hard and durable building-stone, apparently somewhat calcareous. The uppermost layers are grey and brown sandstones, alternating with Ponent red shales. Traced E. from the river, the two oppositely-dipping broad belts of these rocks are seen to coalesce 4 miles from the river, and thence onward to occupy the whole area of the inner and proper "Stone Valley." The rolling country formed of the Vergent flags and shales in the centre of this district, though cut up within by denudation, presents well-defined escarpments towards Rocky and Warrior ridges on the S.E. and N., and

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is of course separated from the latter by the valley of the Cadent black slates, and other lowest members of the Cadent series. Part of this escarpment is Stone Creek Ridge, so called, opposite Couch's Forge.

Traced W. from the river, these opposite outcrops of Vergent slates and flags become regular lines of hills. The S. Clear Ridge, running along Hare's Valley between Jack's and Terrace mountains, is capped by hard grey and dull-brown sandstones, and furrowed at regular intervals down its steep S.E. side. Beyond Chilcoat's it becomes more regular, and acquires a broader summit as its dips grow flatter. Its W. side displays Ponent red shales and sandstones, and overlooks the narrow Groundhog Valley, which separates it from the Terrace Mountain, or Sideling Hill. The N. outcrop runs between Terrace Mountain and Warrior Ridge through Woodcock Valley, and may be divided into four parallel ridges. That next the Terrace Mountain, being two-thirds its height, is called Allegrippus Ridge, and has a broad rolling summit. In any one of the deep gaps through this along the river the successive Ponent, Vergent, Cadent, and Meridian strata may be seen. In the vale between the ridge and mountain flows the Raystown Juniata, cutting alternately and deeply into the base of each, but never issuing into the open Woodcock Valley.

The second ridge, and next N. of the Allegrippus Ridge, has no name, but is continuous. The third is called Piney Hill, and has a narrow summit, along which at one place, 13 miles from Huntingdon, there runs a road, whence we may obtain very fine views of the valley. The fourth ridge has no name; it is the first hill of slate S. of the Warrior Ridge: it has been swept away in many places for the length of miles.

Ponent Series.—This consists of alternating red, bright red, and brown fine-grained sandstone, with red shales, frequently micaceous. At the upper portion of the formation the whole becomes coarser and more silicious, and includes buff and greenish sandstones. They rise high upon the S. flank of Sideling Hill, the N. flank of Terrace Mountain, and the end of Terrace Knob, perhaps three-fourths their height; the lower limit of the series stretches out along the medial line of the synclinal trough for a distance of 4 miles N.E. from the river, and mounts upon Clear Ridge on the S. and Allegrippus Ridge on the N., almost to the summit of each.

CHAPTER II.

HARE VALLEY.

This valley has been sufficiently described in the last Chapter, as it is but the prolongation of the North-dipping nearly vertical outcrops of the Surgent, Pre-meridian, Meridian, Cadent, Vergent, and Ponent series extending S. out of the Valley, and between Jack's Mountain on the S.—an anticlinal ridge of Levant sandstones—and Sideling Hill on the N.—a monoclinal mountain outcrop of the Vespertine conglomerate.

Topography.—Jack's Mountain, prolonged beyond the river, has been alluded to already as containing a double anticlinal axis, conferring upon it three parallel summits. The North-westernmost summit is deeply notched nearly opposite Chilcoat's, or between 5 and 6 miles

S.W. of the river. Looking upward through this gap from Hare's Valley, one sees behind it the high Silvermine Knob. S.W. of this gap the crest of the mountain is irregular, rising into knobs, one of which, called Standerfer's, is one of the most elevated points or summits in all the region. It is well seen from Shirley's Knob in Trough Creek Valley. The junction of the separate crests of Jack's Mountain at its S.W. end is also a striking object. (See Fig. 102.)

FIG. 102.—Standerfer's Knob (a), and side view of Jack's Mountain.

Hare Valley is traversed by Rocky and Clear ridges ; the first composed of Meridian sandstone, the second of Vergent flags.

Fossiliferous Iron Ore.—The Surgent ore ranges along Jack's Mountain, but was observed only at its S.W. termination, round which it folds. The calcareous shales or ore strata are finely exposed on Three Spring Creek, half a mile from Three Springs, just below the road. Some of the layers consist of pure good blue limestone; others are more silicious, interstratified with calcareous olive-shales. The dip is 50°, decreasing into the mountain. An outcrop of the fossiliferous-ore stratum is crossed by the road from Three Springs to Bell's Furnace.

The Scalent and Pre-meridian limestones are opened at Chilcoat's, 30 yards from the base of Rocky Ridge. The strata are silicious, abounding in fossils, and are fetid when struck. The purer Scalent bands lie from 20 to 50 feet further E., and dip nearly vertically. The same beds, with the same character and dip, were opened at Cootsley's, 5 miles to the S.W. of the quarry last mentioned. The road through Rocky Ridge to the Three Springs, near Green's, crosses this outcrop.

Impure, Cadent, bluish calcareous sandstone, or sandy limestone, occasionally fossiliferous, and representing the cement layers, is to be seen on the Juniata and on Cootsley's farm, between his house and Rocky Ridge, near the base of the ridge.

CHAPTER III.

WOODCOCK VALLEY.

THIS valley is enclosed between Terrace Mountain on the S.E. and Tussey Mountain on the N.W., and at Bloody Run opens into Black Valley, which continues to the Maryland State line.

Before entering upon the general description, it will be useful to make some remarks respecting the characters of the several formations occupying this belt of country. The Surgent shales and the adjoining subdivisions become visibly thinner as we trace them towards the S.

The Scalent and Pre-meridian limestones, finely exposed on the Bedford turnpike W. of Bloody Run, exhibit very silicious and argillaceous layers below, pale, milk-white, fetid, and more fissile blue and almost black layers in the middle, with large zoophytes and silicious limestones, containing shells and Encrini, above. The formation is here accompanied by iron ore.

The Meridian sandstone is from 70 to 100 feet thick upon the Juniata, and increases in thickness Southward, and forms a ridge across the Maryland line two-thirds as high as Tussey

Mountain itself. The buff layers of the Stone Valley are not observed to form part of the formation in this district.

The Cadent and Vergent series seem to thin Southward, the latter beginning here to display near its upper limit a peculiar stratum of coarse conglomerate. This is exposed on Coffee Run in Allegrippus Ridge, and along the river bank at Stonerstown, as it crosses the river from the opposite high bluff. It is a mass of quartz pebbles, cemented by a bluish paste, from 10 to 15 feet thick. Its position in the series causes its outcrop to range along the summit of the Allegrippus Ridge, and its debris may be seen at the foot of this ridge at Leman's Forge. Traced onward in this direction, it passes at the State line a shallow trough on the summit of Big Mountain, near the road passing from Hoare's to Townhill Gap.

Woodcock Valley is essentially monoclinal, and therefore simple in structure, lying between the Levant strata of Tussey Mountain and the Ponent of Terrace Mountain, and is composed of the intervening formations. (See the annexed Section, fig. 103.)

FIG. 103.—Woodcock Valley at M^{c}Connellstown.

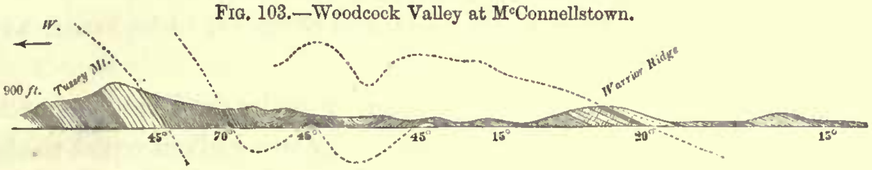

FIG. 103—*Continued.*

Levant Series—Tussey Mountain, &c.—From the synclinal knob overlooking Hartzlog Valley north, and that of the Juniata, Tussey Mountain runs nearly S. 30° W. until opposite Trough Creek Gap, where some small flexures throw it forward in a shoulder-like projection into Woodcock Valley. Again it preserves its course, until sharply recurved, at the knob opposite Bedford Forge, by an anticlinal issuing S. from Morrison Cove. The mountain retreats N. 3 miles to the head of the synclinal ravine, and then comes forward again, and pursues nearly a straight direction to the Maryland line, a few miles S. of which, having united with the W. barrier of Morrison's Cove, it abruptly terminates. In all this distance it is breached at the streams only five times, forming as many water-gaps. The small parallel anticlinal flexures of the Surgent shales and marls, which have been described as traversing Stone Valley and crossing the Juniata, continue to affect those formations beyond M^{c}Connellstown. Three of them may be seen in traversing the valley at that place, where also some beds of limestone show themselves beneath the red shale. Their last traces are discerned in the section opposite Trough Creek Gap, where also one of the smaller flexures brings up the limestone which underlies the red shale. In the parallel of Stonerstown these axes have entirely vanished, and an almost uniform dip pervades the valley from side to side.

Surgent Iron Ore.—The low ridge described in the chapter on Stone Valley as marked in the outcrop of the Surgent ore formation, continues through Woodcock Valley, close to the base, and forms part of the slope of Tussey Mountain. In only one place was the ore observed to be brought to the surface by any of the small flexures seen in the sections. The anticlinal which issues from the S. loop in Warrior Ridge, lifts the ore on two hills, one mile S.S.W. of McConnellstown; the W. hill is three-quarters of a mile from Mr Patten's house on the one side, and half a mile from the foot of the mountain, where the final outcrop of the ore is to be sought, on the other. (See Fig. 104.)

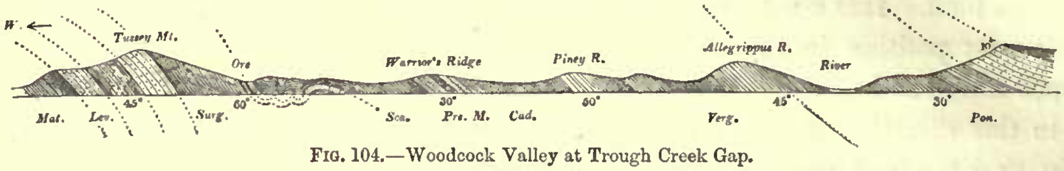

FIG. 104.—Woodcock Valley at Trough Creek Gap.

Extensive openings on the ore have been made at Savage's, opposite the shoulder of the mountain, 15 miles from Huntingdon, and 500 yards W. of the Bedford road. The principal stratum, at the time of examination, varied from 20 to 25 inches in thickness, was overlaid by the encrinitic sandstone, and this again by yellow slate, the dip being 45° E.S.E. The ore was more fissile and more fossiliferous than at Danville, and promised to be harder at an equal depth below the surface.

In the same range are the Hopewell Diggings, nearly opposite the Furnace, and 2½ miles distant, and 500 yards W. of Warrior Ridge. Here the ore is in two beds of equal thickness, averaging 2 feet, sometimes in contact, and sometimes separated by 8 feet of slate; the lower bed is of the hard calcareous variety. Two analyses of specimens from the upper bed, from points at and below the surface, gave, for the former, 54.92 per cent iron, for the latter 38.64. Troublesome faults or down-throws are of frequent occurrence in these ore-beds.

The ore is seen dipping 35° S. on the road over the end of Tussey Mountain, but is harder and poorer than in the last-mentioned locality. The anticlinal axis, issuing from the end of the mountain opposite Bedford Forge, crosses Yellow Creek between McDowell's Ore Bank and the road that passes the Post-office, within 100 yards of James Piper's house, in red shale, and dies out before reaching Warrior Ridge. It causes, of course, two outcrops of the ore formation, which gradually approach each other, and at length come together as the axis subsides. The outcrop upon which the former openings are made, after crossing Yellow Creek, recrosses it at the McDowell Banks, runs up the synclinal cove or ravine, and comes back again upon the flank of Tussey Mountain, crossing Yellow Creek for the third time on its way S.

At Davis's openings on the hill S. of Yellow Creek, and upon both sides of the anticlinal, the upper stratum of ore is 2 feet thick, the lower 22 inches, with an interval of 8 feet. The upper stratum is a little softer than the lower, the latter containing as a parting an inch or two of slate. These were the conditions at a depth of 22 feet below the surface. But in another shaft, placed lower in the hill, the ore-beds were each about 18 inches thick, and were separated by slate and a single layer of slightly encrinitic argillaceous sandstone.

Burkett's openings, further S. upon the axis, resemble those next to be described, or McDowell's openings, which are situated in the W. outcrop, have a dip of 35°, and exhibit three beds. The uppermost of these is 3 feet thick, having a roof of compact olive slate, and resting upon a silicious and sparry limestone, which, in a stratum of 8 feet thick, separates it from the middle ore-bed next below. This middle bed is thin, very calcareous and silicious, and underlaid by a stratum of fossiliferous olive-shale one foot thick, beneath which we come upon the *lowest bed* of ore, having here a thickness of about 2 feet, and a quality sometimes better than that of the uppermost bed. By analysis, it has furnished 27.72 per cent of iron.

Two beds of ore present themselves at the outcrop on the Creek, one quarter of a mile above the forge, the upper one 22 inches thick, the lower thinner. It is here of better quality than at the last locality, but still very calcareous. It dips W. at an angle of 30°.

At Cogan's openings, 2 miles from Bedford Forge, at the foot of the mountain, an ore occurs which, from the deep red hue of some specimens, and their included scales of black oxide of iron, would seem to be the prolongation of the deposit already traced. Here, however, the harder lumps or masses found in the generally soft stratum prove to be a light brown and rather cellular ore, which is sometimes sandy and hard, sometimes ochry. Its dip is at least 40° E., and the bed, as reached by a shaft 100 feet deep, is said to be 4 feet thick. If not a continuation of the fossiliferous ore under a somewhat altered aspect, it will be found to belong to a group of strata below it.

For many miles S.W. of Bloody Run, no ore-ridge crests separate themselves from the mountain. At the first gap S. of the river, the encrinitic Ore-sandstone begins to form a low ridge. This increases in height until it crosses the State line, and exposes, as in Stone Valley, great blocks upon the surface, assuming, where weathered, an ochreous colour. The specimens of the ore which were examined were of so silicious a composition as to make the value of the deposit doubtful.

Pre-meridian and Meridian Series—Warrior Ridge, &c.—From the Juniata River to McConnellstown, the Warrior Ridge narrows rapidly, by the issuing of its several anticlinal flexures, into the Surgent marls and shales upon its W. side. At McConnellstown its summit consists of two narrow ridges, one of them formed by the outcrop of the Scalent and Pre-meridian limestone, the other by that of the Meridian sandstone. These soon coalesce, and the sandstone alone forms its summit, as traced into Maryland. Innumerable little tributaries of the Raystown branch cut through it in its course. It is sometimes so smooth and low as to be entirely cultivated. Elsewhere, as at the very high knob near Lemnos Works, it is bold and rugged. This knob is nearly upon the line of the anticlinal axis which issues from Morrison's Cove, but is composed of Pre-meridian limestone, and has its W. slope thrown into a series of terraces by limestone strata of the Scalent series, all dipping at an angle of 45° E. The axis then bends the ridge towards Tussey Mountain, causing it to cross the river a short distance W. of the village of Bloody Run.

Three or four miles beyond the Maryland line, Warrior Ridge unites with the ridge of Bean's Cove, round the end of Tussey Mountain. From Bloody Run to the State line it is bolder and less broken than in Woodcock Valley, and even rises at the line to a height equal to two-thirds of that of Tussey Mountain.

Black Oak Ridge.—Black Oak Ridge is the product of a remnant of the Pre-meridian and Scalent limestone strata of Warrior Ridge, lying along the axis of the synclinal trough, behind or W. of the anticlinal that issues from Morrison's Cove. (See Fig. 105.)

FIG. 105.—Section of Black Oak Ridge.

The thickness of the two limestones in this region may be estimated at 300 feet; that of the Meridian sandstone in Woodcock Valley at 100 feet.

Iron Ore connected with the Lower Layers of the Scalent Limestone.—This is a brown argillaceous ore, enclosed in thinly-laminated calcareous strata.

At Casper Flecker's, 7 miles from the forge, the deposit lies in nests, bearing in part a rich brown ore, traversed by seams of beautiful hæmatite, and resembling the Matinal ore, and in part shelly and very meagre.

At King's, 5 miles from the forge, the openings, as at Fluke's, are on level ground, sink-holes appearing along the outcrop of the limestone, not far distant to the E. The ore is here overlaid by a yellowish-white clay, resembling the Vespertine ore at the Hopewell Bank, on the N. side of the river. Between these two localities numerous shafts were sunk without finding it.

The structure of the rocks near some large openings N. of the turnpike road, near Bloody Run, is difficult to comprehend. The first and only trace of red shale, after leaving the limestone quarries at Warrior Ridge, is seen on entering the river-gap, where the dip is 30° E. Not 100 yards W. of this, the Levant white sandstone is boldly exposed, dipping 70° E., and, further on, the red sandstone stands vertically. It is conjectured that a fault occurs between the Scalent limestone and the Surgent slates, nipping out the marls and shales, and leaving but a small residual exposure of red shale. If so, the course of the river must mark the line of a transverse fracture also, because regularity seems to obtain again upon the S. side of the river.

Iron Ore is scattered in abundance, often in large porous masses of fair quality, along the base of the mountain on Mr Lail's land. At the time of examination, shafts were sinking by Messrs Lay and Patten, and some of the ore was found to be very rich, of a brown hue, and much like the best in King's Banks.

Cadent, Vergent, and Ponent Series—Allegrippus, Clear Ridge, &c.—All the country between Warrior Ridge and Terrace Mountain is occupied by Cadent, Vergent, and Ponent formations, the Raystown Juniata flowing for many miles in a valley of the latter.

The Cadent and Vergent formations manifest in this region a surprising distinctness. Four parallel ridges fill up the interval between the Pre-meridian ridge last described and the Vespertine-capped Terrace Mountain. The highest is Allegrippus Ridge, next the mountain overlooking the river, flanked by Ponent red shales, and showing upon its broad and often triple summit the outcrop of its peculiar conglomerate, already mentioned. A second ridge, usually distinct, sometimes coalesces with the Allegrippus. Piney Ridge comes next, and between it and Warrior Ridge runs a fourth. A glance at the sections will show that these parallel ridges are constructed in the simplest manner, being merely elevated outcrops of harder masses of flag strata, that alternate with the more shaly formations of the series.

The strata of the Allegrippus Ridge are finely exposed by the violent traverses of the river in its narrow valley. The exposures, as at Kisslinger's Ford, 5 miles from the mouth of the branch, those at the mouth of James Creek, and those at Stonerstown, are well deserving of examination. The last-mentioned extend W. even to the rocks of the base of Piney Ridge.

Near the Norris Notch in Terrace Mountain, Allegrippus Ridge curves slightly as the dips increase S., and bears S. 25° W., so as to approach close to the mountain, keeping the iron-bearing strata in the narrow interval. Ranging just W. of Lemnos Works, it continues as a lofty ridge to John's Branch, at Chamberlain's Mill. From this to the turnpike it is less conspicuous, but S. of the Juniata it runs on in the lofty Clear Ridge to the State line.

Piney Ridge carries its sharp low summit well defined as far as John's Branch.

The Fourth Ridge, called at Stonerstown the Backbone, is in many places washed away, because composed of the older Cadent shale, with very little sandstone. These shales pass downwards into the older black slate towards the Warrior Ridge, which along this line, as so often elsewhere, have been mistaken, and opened for coal slate.

Between the turnpike and the Maryland line these separate groups are less distinct. Only one ridge instead of three can be traced with any regularity between the Warrior and Allegrippus ridges. This middle minor ridge is sometimes called Milk-and-Water Ridge, from the name of a creek that flows along its foot.

Iron Ore occurs in the Cadent older black slate at Stephen Wyman's, 3 miles from Bedford Forge, towards Huntingdon, at the foot of Warrior Ridge, and in connection with layers of fetid argillaceous dark limestone. The ore thrown out was shelly, mixed with brown clay, and sometimes in the form of flattened bombs.

Similar ore was found by Mr Steele 3 miles from Savage's. The same was again opened for the Hopewell Furnace, at General Piper's, on lands sloping steeply E. Some of the ore was largely cellular. Renard's opening on the same line, 3 miles further S., exposed rather better ore.

CHAPTER IV.

TUBMILL HARBOUR AND THE COUNTRY SOUTH OF IT.

Terrace Mountain, at its S. end, curves backwards under the name of the Harbour Mountain, by virtue of the great synclinal flexure of the Broad-Top region, and forms a wide cove by resuming its S.S.W. course, when it takes the name of Wray's Hill.

The country thus enclosed between the Harbour Mountain and Wray's Hill on the N. and E., and Clear or Allegrippus Ridge on the W., is not intricate. Tubmill Harbour, its N. end, is a wild region, watered by two small creeks, and traversed by innumerable small flexures in the Cadent, Vergent, and Ponent slates and sandstones, which spread out those formations in a rolling table-land from the Clear Ridge to the foot of Wray's Hill. Over this table-land N. of Brush Creek, nothing is to be seen but red argillaceous sandstone of the Ponent series, occasionally alternating with the grey and bluish Vergent flags.

Approaching the latitude of Clairville, the table-land resolves itself gradually into five different ridges, making, with Clear Ridge, and in obedience to the three controlling anticlinals of the region, six parallel outcrops of the massive Vergent flag formation. Thus, anticlinal and synclinal valleys alternate from Clear Ridge to Wray's Hill. In the former come up the Cadent shales, in the latter lie the lowest Ponent slates and sandstones. The former widen as they run S., and debouch upon a rolling plain in Maryland ; the latter head up, lose their Ponent contents, and stand out as bold Cadent and Vergent knobs.

Thus Clear Ridge, or Polish Mountain, and Ragged Mountain, unite near the State line, and run on as a synclinal belt of Cadent and Vergent rocks in Big Mountain into Maryland. Tantellinger's Ridge and Black Oak Ridge unite and terminate as Big Mountain not so far S. as the Line. Shaver's, or Racoon Ridge, and Hooppole Ridge, unite, and, running a still shorter distance, terminate in a third synclinal knob overlooking Sideling Hill Creek. Close by its termination this latter range is twice cut down to its base by gaps, through which flow branches of the latter stream.

A seventh range, Adder's Ridge, remains to be described. It is a belt of Cadent and Vergent rocks that accompanies Wray's Hill, as Allegrippus Ridge accompanies Terrace Mountain, with dips of 45° E. In Maryland it is called Green Ridge, and displays the conglomerate stratum, before mentioned, along its summit.

A section made along the National Road, from Polish Mountain to Adder's or Green Ridge, exhibits only Cadent and Vergent strata, and these tortured by a thousand minute flexures, which are included in the larger waves just described. The W. dip in Polish Mountain is here 10° or 20°; in Adder's Ridge it is 45°. The Vespertine sandstone in Town Hill dips 20° or 30° S.E. The Ponent series contains many layers of buff and greenish sandstone. Some of the beds are bright red, others dark-brownish red, and highly micaceous.

CHAPTER V.

THE BROAD-TOP REGION.

Topography.—Before describing the Broad-Top coal-field itself, with the elevated plateau of the seral or coal conglomerate which sustains it, the Vespertine mountain-rim in which it is set must be noticed. This is called Sideling Hill on the E., and Terrace Mountain on the W., and Harbour Mountain on the S. Sideling Hill and Harbour Mountain unite, and pass S. from the S.E. corner of the district in a broad synclinal summit, but they separate again, to enclose the long and tapering synclinal trough, the Vespertine red shale valley of Brush Creek, which comes to a point at the end of Wray's Hill, near the State line. But about half-way along this valley, and mid-way from its E. mountain-wall, there runs S. into Maryland another and parallel Vespertine synclinal mountain, which retains the name of Sideling Hill. Between it and the E. barrier of Brush Creek Valley lies Whip's Cove.

Vespertine Strata.—The rocks of the Vespertine conglomerate may be studied in all the gaps which intersect these several mountain-walls, and through which issue all the streams of the interior valleys. Such are the gaps of Trough and Yellow creeks, and Renard's Run in Terrace Mountain, of Brush Creek in Wray's Hill, and of Sideling Hill Creek in Sideling Hill.

The lower coarse grey, yellowish, somewhat argillaceous, and obliquely-bedded Vespertine rocks, are seen alternating with the uppermost red Ponent sandstones. Next to these, as at the beautiful spring 100 yards below the forge in Trough Creek Gap, are friable buff-coloured slates, stained with oxide of iron. These overlie the principal mass of coarse micaceous sandstones, tinted grey and white. The uppermost of these are massive quartzose conglomeritic sandstones, even-grained, specked with peroxide of iron, and stained with ferruginous blotches. In these occur thin plates of coal, rarely larger than a flattened stem or leaf, also now and then a thin black slate. Still higher up other yellowish and argillaceous sandstones come in again, forming the inner slope of the mountain, upon which lie red and greenish shales, at first alternating with the sandstones, but soon constituting a formation by themselves, filling the inner valley, and rising upon the central Broad-Top Mountain all around its flank. In these alternations of sandstone and red shale occur the beds of iron ore and limestone presently to be described.

A full suite of specimens of all these strata might be gathered from the fine exposures in Yellow Creek Gap. The false bedding is everywhere characteristic of the Vespertine sandstones. The conglomeritic layers are rather less abundant. They are somewhat esteemed for the manufacture of millstones, but blotches or soft pebbles of red sandstone often disfigure and injure them, and they require constant dressing to keep them sharp. They appear on the spur of Harbour Mountain jutting into Well's Valley, and contain large milk-white pebbles. When these are closely cemented, the stone is good ; but the French Buhr-stone is greatly preferable to any Vespertine millstone, especially when wheat is to be ground.

As the soil produced from these rocks is far from fertile, and as numerous flexures bring them to the surface in Trough, Brush, and Wells' valleys, much of the land is left in the wild stony state called " Barrens."

Iron Ore.—The alternating strata between the Vespertine sandstone and Umbral red-shale formations contain an iron ore which varies greatly in quantity and quality in different localities, although it is supposed to outcrop regularly around all the synclinal valleys of the Umbral series in the district under description.

The old openings for the Trough Creek Furnace are at the base of Terrace Mountain, about one mile from the forge, and on the supposed outcrop of a continuous bed. The ore occurred in balls, closely imbedded in a little earth, and was of five varieties. Several of these were very compact kinds of the common brown ore, seldom exhibiting any hæmatitic structure, but having a smooth jaspery surface and brittle fracture. The upper bed is of a dark lead-colour, and very heavy, containing manganese, giving its iron a brittle character.

The Hopewell ore-openings display the ore-bed on both sides of the gap ; but a tunnel 90 feet long reached the bed upon the S. side of the gap, 90 feet below its outcrop, where it is from 20 inches to 3 feet thick, interposed between the sandstone below and the red shale above, and interstratified with more or less of clay. It is of three varieties. The most abundant is brown and brittle, with a jaspery fracture ; it makes good iron, and is said to yield fifty per cent. A second species is yellowish and slaty. The adjoining red shale lies in thick but very soft strata, is friable, and of an intense red colour next the ore. Thin layers of a more sandy ore are interleaved with the silicious red shale near the ore-bed. On the other side of the gap the coarse yellowish-white sandstone is seen again to form the immediate floor of the ore-bed, and is impregnated with iron in a remarkable degree.

This ore has been traced along the edge of the barrens adjacent to Little Trough Creek, and on the farms 2 miles from Chilcoatstown. It is probably an original deposit, and may prove as valuable here as at the gaps in the ridges.

The ore was traced into Groundhog Valley, and has been mined at Ford's, and at the foot of Harbour Mountain, but manganese impairs its value. It has been followed round the whole circuit of Brush Creek Valley. The " ore tract " passes Barton's, and runs along the base of

Scrub Ridge, a spur of Sideling Hill. Fragments of hæmatite, sometimes mamillary, but frequently slaty, and of quality inferior to that already described, cover the flat ground at the foot of the long and gentle slope.

The outcrop traverses Furney's land, along the base of Wray's Hill in the S. end of the valley, where large masses of ore lie upon the surface—a phenomenon due, perhaps, to the fact that the dip happens here to coincide with the slope of the mountain. The specimens seen were generally of a light chestnut colour, slaty, and veined with hæmatite. It shows itself also on Breathhard's property adjoining, and is in great abundance on that of Mr James, where much manganese is again found in it.

Umbral Limestone.—A somewhat silicious limestone, slightly fetid, of a sparkling grain, and generally of a greenish or clouded white and greenish colour, makes its appearance in the shales above the iron ore. It measures only 3 or 4 feet in Trough Creek Valley, but grows thicker further S. It is seen 12 feet thick in Groundhog Valley, half a mile from Reinhardt's mill, and at least 20 feet thick at Furney's, Breathhard's, and other places in Brush Creek Valley, where deep sink-holes mark its outcrop.

Distribution.—The limestone lies in a horizontal position on Little Trough Creek, above the road from Chilcoatstown to the furnace; the lower layers are coarse, are 2 or 3 feet thick, and are overlaid by the same thickness of red limestone, and this again is covered by calcareous red shale for 20 feet. Lovel's limestone, better in appearance, produces a darker lime. The outcrop runs along the edge of the "Barrens," through Hazard's land, where it appears among layers of sandstone.

Along Sideling Hill the thin limestone has been opened at Sideling Creek Gap. Near the furnace it is quarried on the S. side of the creek. Here an impure red limestone, 6 feet thick, rests upon grey sandstone. Above it are two layers of grey limestone, 3 feet thick. A red calcareous shale, with red argillaceous concretions, is traversed by bitter spar, and is sometimes overlaid by a stratum of impure limestone. Through Plank Cabin Valley, the creek flows along the junction of the sandstone and shale, and the limestone occurs, therefore, always on its S. side.

The outcrop may be traced through Little Valley, crossing the road which runs from Barnett's to Stonerstown, and it is cut through by the Hopewell furnace-tunnel.

Not a fossil could be discovered in this bed of limestone at any locality within the Trough Creek belt, although they are numerous in it W. of the Alleghany Mountain.

In Wells' Valley the numerous flexures of the strata bring up the limestone frequently along the creek. At Wishard's Sawmill, one mile from Speer's, red and grey crystalline beds of it appear, containing one or two fossils, a bivalve shell, and a coral, &c. Other quarries are opened in the W. bank of the creek, where it flows along the limit of the shale towards the gap.

In the N. end of Brush Creek Valley, near Scrub Ridge, the limestone has been quarried, and it appears again just W. of Aker's house, and upon all the farms along Wray's Hill. At the gap it is seen 50 yards above Lodge's house. In the neighbourhood of Furney's and Breathhard's it must underlie much of the surface of the valley, the dips being very gentle, with probably flat wide rolls. Further S. it does not seem to exist.

Shales and soft argillaceous sandstones form the chief strata between the limestones just described and the base of the Seral conglomerate. These become more silicious as they approach the conglomerate, and in the form of green, buff, and hard reddish argillaceous sandstones, embrace impure calcareous beds, and are of great thickness, reaching even to the summits of the knobs and spurs which project from the Broad Top and Wray's Hill into the red-shale valleys. Thus on the road to Howck's, from Plank Cabin Valley, these alternations stretch nearly to the top of the slope of Grave Mountain. At one locality, in their lower part, a highly silicious dark-green limestone stratum was discovered, which contained layers of slate.

These strata are exposed by Trough Creek, in the short spur of Wray's Hill opposite De Forrest's, where the lower beds consist of fine-grained red and green compact shale, or argillaceous sandstone; the upper of green, massive, and coarser, but not very compact. These are used for whetstones. Thick coarse-grained strata of grey and greenish sandstone traverse the general mass of green and red silicious shales, along Wray's Hill, below the summit, and render it difficult to determine the lower limit of the Seral conglomerate. Specimens of a light chestnut-coloured iron-ore are to be seen upon the surface, in ascending from De Forrest's to Sturmburg's coal-diggings, and on Mr Deever's fields. The relative positions of these beds will appear from the following observations, made upon the flank of the Broad-Top Mountain, half a mile below Riddlesburg, and descending from the Seral conglomerate to the bank of the river.

Umbral Rocks in the Flank of Broad-Top Mountain.—Seral conglomerate, not 100 feet thick, the lowest coal-bed above it being only about 100 feet above the upper Umbral limestone; interval of a few feet unknown.

Silicious slate, dull brown; 10 feet.

Limestone, hard, silicious, reddish, embracing plates of red shale; its fragments strew a blank space of 40 feet, occupied probably by red shale below its apparent outcrop.

Sandstone, fine-grained, micaceous, green, passing downward into olive shale; 20 feet.

Sandstone, grey, 3 feet exposed—interval, probably red shale, 10 feet; sandstone, laminated greenish-grey micaceous, 3 feet exposed; shale and fine micaceous argillaceous sandstone, 20 feet.

Sandstone, ferruginous, massive, close-grained.

Sandstone, coarse-grained, massive, quartz-grains in contact, distinct, and apparently cemented only by an oxide of iron, and resembling specimens of the Surgent block-ore, such as exist in Middle Creek Valley, near Beavertown, Union County. This is 3 feet thick.

Sandstone, rather massive, greenish, interstratified with green and red shales; 20 feet.

Sandstone, dirty green, micaceous, pretty compact, becoming micaceous, brown, and very ferruginous, downwards; 13 feet thick.

Limestone, 2 feet thick, greenish, very silicious, with pebbles and plates of green shale, hard, and weathering with a worm-eaten aspect.

Sandstone, green argillaceous, micaceous, laminated, 7 feet; interval, 45 feet.

Sandstones, light-brown, micaceous, laminated beneath the red shale at the river-bank.

Little has been said concerning the stratigraphical condition of the district under discussion, because in the main it is simple, although locally somewhat complicated by numerous contortions of the strata. These will now be noticed so far as may be needful.

The Umbral red shale, spreading over the elevated Trough Creek and Plank Cabin valleys, encircles the central coal region on every side, forming a narrow gulf between its Seral and Umbral sandstone cliffs, and the Vespertine conglomerate and sandstone mountains opposite and around them. This fact should dispel the fancies entertained by many, of finding coal upon either the Terrace, Sideling, or Harbour Mountains. The coal is confined to the centre of the synclinal basin—to the actual summit, indeed, of the Broad-Top Mountain, of which the mountain united to it by Lane's Loop, improperly called Wray's Hill, forms a part. No description can convey a knowledge of the contour of the mountains as they circle round the central plateau, and stretch away along the synclinal region Southward. A glance at the Map will, however, make their connection clearly apprehended. But the several anticlinal flexures which govern their distribution and shape must be noticed.

Trough Creek Valley.—The synclinal axis of Trough Creek Valley, like that of Stone Valley, does not follow the middle line of the valley, but ranges along the base of Sideling Hill. Shirley's Knob and Rocky Ridge lie along the axis-line of the trough.

Trough Valley at Chilcoatstown is 8 miles wide, and the axis passes within one mile of its E. barrier. The Umbral red shales fill the trough for a breadth of 2 miles from the base of Sideling Hill; the other 6 miles, to Terrace Mountain, consist of a gradual ascent of Vespertine sandstone strata, forming the Barrens. The high terrace-knob at the head of Trough Valley offers a fine position for a bird's-eye view of this phenomenon. The unbroken crest of Sideling Hill bears from it S. 25° W. with nearly vertical strata; and that of the Terrace Mountain S. 50° W. to Trough Creek Gap, its inner slope scarcely a perceptible rise, and irretrievably barren, rendering more striking the fertility of all the land on the S. side of Trough Creek. It forms the limit of the Barrens, by obeying the general drainage law of the region, and flowing at the contact of the shale and sandstone.*

FIG. 106.—Section of Trough Creek Valley.

This great outspread of rocks upon the W. slope of the synclinal axis is due to the dying-out N. of numerous minor flexures, which issue from the Broad-Top Mountain, and form spurs along its N. flank.†

These flexures undulate the red shale floor of Plank Cabin Valley, which is merely the portion of Trough Creek Valley lying S. of the creek.

Five flexures mark unmistakably the structure of the Broad-Top Mountain: The First, upon the E., runs in between Wray's Hill and Shirley's Knob, or Rocky Ridge; the Second, between Rocky Ridge and Round Top; the Third, between Round Knob and Grave Mountain, although these are apparently united; the Fourth indents the wide cove between Grave Mountain and Broad Top; the Fifth (through, or perhaps W. of, Round Top), between Broad-Top and the nameless spur next to Terrace Mountain. The synclinal troughs on the summits of the intermediate spurs or knobs will be described hereafter with the coal. The third anticlinal is evidently the master-flexure of the region, almost sundering the E. and W. portions of the Broad-Top synclinal, and after passing through Harbour Mountain, representing itself by the Fair View or Tubmill Harbour anticlinal.

A similar series of flexures—not one of them—except perhaps the middle one, just mentioned—the same with any one of the N. series—escape from the S. side of Broad-Top Mountain, traverse the Umbral red shale, and enter Harbour Mountain. Several issue from little loops on the side of N. Wray's Hill, and are lost in the shales of Wells' Valley. But so intricate are these waves, and so barren are they of exposures, that, at the time of the exploration, insurmountable difficulties impeded the progress of detailed investigation.

Proceeding S., the dips of Terrace Mountain steepen, being at Trackmen's Gap 15° S. 59° E.; at Stoup's Run Gap, 45°; at Yellow Creek, 55°; at Renard's Run, 50°. Before the junction of Terrace with the Harbour Mountain, its summit is much broken and degraded—the Harbour Mountain towering above it from behind, and its rocks dipping only 25°.

The dips of Sideling Hill, at first very steep, decline on passing S. of the Gap of Sideling Creek, and the W. slope of the mountain stretches far out into Wells' Valley, which, as it heads up S., is wholly occupied by undulations of the Vespertine conglomerate, supporting "barrens," the Umbral red shale being altogether swept out of the shallow basin. Not a remnant of that formation appears upon the turnpike. Thus a broad undulating

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* Another very admirable point of view is Standerfer's Knob on Jack's Mountain, where the natural line of the edge of the Barrens, and edge of the fields, is very evident.

† It is probable that one of these flexures has produced that singular projection of Terrace Mountain west of Norris' Notch. The only rocks observed in place were upon the N. side of the notch, and dipping 30° S. 45° E. A cross fracture and down-throw are not to be conjectured, as then the mountain would be cloven to its base by what is now simply a notch in its summit.

plateau of the Vespertine rocks unites S. Wray's Hill and Sideling Hill, and forms the watershed between Wells' and Brush Creek valleys. Into the latter these anticlinal undulations project their proper spurs. At the turnpike this sandy plateau is 7 miles broad. Brown ponent sandstones appear in some deep ravines, trenched out from its E. edge, and may have been brought up nearer to the surface by the Whip's Cove anticlinal, running up thus far N. in the E. mountain-barrier of the Brush Creek Valley.

The two spurs of the Vespertine watershed, projecting into Brush Creek Valley, contain two dying anticlinals, subdividing its head into three little synclinal coves of the Umbral red shale. The opposite dips of the walls of this synclinal valley seldom exceed 15°; those in the spurs are sometimes 30°. Scrub Ridge, an extension of the Easternmost of these spurs, has preserved behind it a patch of red shale, the whole of which is covered by two farms, surrounded by the Vespertine sandstone barrens. Opposite the gap the valley is 3 miles wide, the arable red-shale land remaining in it being only 1 mile wide. At Furney's, the Southernmost house, 4 miles from the foot of the valley, its width is only 700 yards. Two anticlinal axes are supposed to traverse the Ponent rocks of Whip's Cove. One of them runs along the foot of Sideling Hill, and enters a projection of that mountain 3 or 4 miles N. of the Conoloway Gap. One of its dips near the gap is 30° S. 65° E., soon rising to 70° as we leave the mountain, and becoming at length vertical; the other, on the N.W. side of the cove, is 10° or 15°, but at Smith's house, 2 miles distant, it is 45°. Along the National Road there are no indications of great anticlinals, but a succession of undulations seem to characterise this, as every other portion of the great synclinal belt of the Broad-Top Mountain.

DIVISION V.

OF THE FIFTH BELT OF THE SIXTH DISTRICT, OR THAT BETWEEN THE BALD EAGLE AND ALLEGHANY MOUNTAINS.

PRELIMINARY REMARKS.

THE long valley enclosed by the Bald Eagle Mountain on the S.E., and the Alleghany Mountain on the N.W., has already had its general features sketched in our description of the orography and scenery of the Second District or Appalachian Chain of the State. Its geological structure now claims attention.

It is a great monoclinal belt or slender tract, including all the middle Palæozoic strata of the country save the Post-meridian series—all, namely, from the top of the Levant to the top of the Ponent rocks, and the chief part of these formations on an amply-developed scale, as well in actual thickness as in breadth of outcrop. Though in general structure essentially a monoclinal zone, with a prevailing dip of its numerous contained strata towards the N.W., or beneath the Alleghany Mountain, this is not their absolutely constant condition, for the valley embraces, as will presently appear, a succession of secondary flexures, which here and there undulate its rocks into small anticlinal and synclinal waves, like so many ripples on the slope of a gigantic billow. These lesser alternations of the dip abound most towards the central line of the main valley, where, in some instances, they constitute conspicuous ridges, and may in all cases be detected in the topography or surface contours. The great valley follows the Alleghany plateau like a huge curving trench, itself furrowed into many longitudinal parallel slender vales, and transversely seamed, especially on its flanks, with immense cross-gullies and steep-sloping ravines.

Close along the foot of the Bald Eagle Mountain flow the main streams which water the district; namely, the West Branch of the Susquehanna, Bald Eagle Creek, and the upper tributaries of the Juniata. Flats, more or less extensive, and generally highly fertile, fill the sinuosities of their immediate valleys. Between these plains and the Alleghany Mountain there usually lie two ranges of hills; and these are cut by numerous transverse gorges, by which the smaller waters find their way to the main streams. The first line of hills is composed of Cadent shales and Vergent flags, the second of Vergent shales and the Ponent rocks, and this stretches with great general uniformity of contour along the foot of the great slope of the Alleghany table-land, from which it is separated by a narrow elevated platform or barren terrace. Both ranges present a series of rounded summits, and few exposures of the rocks, except in the transverse gorges; but some of the larger of these afford noble exhibitions of the strata.

FIG. 107.—Typical Section of the Great Bald Eagle Valley.

Lehman W. & A.K. Johnston, Edinburgh

PINE CREEK GAP, LYCOMING Co.

Among the many wide and noble views of mountain scenery embraced within Pennsylvania, none are grander or more beautiful than those procurable from the summit of the Alleghany Mountain in the neighbourhood of the Loyalsock, commanding the whole structure of this great valley, and its relations to the intricate mountain-region bounding it on the S.E.

The village of Muncy, or Pennsborough, is situated at the N. foot of the Muncy Hills, where the Pre-meridian limestone and Meridian sandstones emerge from under them. Immediately on its N. lies a little plain, bounded N. and W. at Hughsville by the Muncy Hills, formed of the two central ranges of summits above spoken of.

Opposite the end of the Muncy Mountain, and upon the E. bank of the river, the Surgent, Scalent, and Pre-meridian rocks are seen in fine exposures arching over its declining anticlinal axis. The N. dips are exposed at Hall's, the E. and S.E. in the Muncy Creek. The buff calcareous middle layers and red shale of the Surgent series range W., covered in great part by the river bed, but frequently appearing in exposures along its N. shore wherever it cuts into the base of the mountain. The river sometimes, on the other hand, makes short sweeps to the N., invading the Cadent and Vergent ranges of hills, in which it makes fine exposures, as at Fairview west of Williamsport, and at Jersey Shore, and E. of Lockhaven.

The Pre-meridian and Scalent limestones, visible one mile N. of Pennsborough (Muncytown), range W. in a succession of low hills, called the Limestone Ridge, to Williamsport; they reappear at Pine Creek in noble exposures, and so continue along the Bald Eagle Valley and its extension S.W. towards the Potomac. Before proceeding to a particular description of the several formations in their local outcrops, I shall give an account of the type which each assumes in this its most N.W. reappearance within the Appalachian Chain.

CHAPTER I.

OF THE CHARACTER OF THE SURGENT, SCALENT, PRE-MERIDIAN, MERIDIAN, CADENT, VERGENT, AND PONENT ROCKS AT THE BASE OF THE ALLEGHANY MOUNTAIN.

SURGENT, SCALENT, PRE-MERIDIAN, AND MERIDIAN SERIES.

In the N.E. portion of the long and narrow belt included between the escarpment of the Alleghany Mountain and the crest S.E. of it, the Surgent and Scalent rocks are, with the exception of the Iron-sandstone and the Ore-sandstone, very largely expanded. The following vertical column exhibits the entire series, together with the Pre-meridian and Meridian strata, as they are to be seen between Muncy and Jersey Shore: it is compiled from several localities. See also the engraved Columnar Sections.

STRATA EXPOSED ON THE WEST BRANCH OF SUSQUEHANNA RIVER BETWEEN JERSEY SHORE AND MUNCY (ALSO AT MILTON).

Meridian.	
Sandstone, ...	very thin.
Slates—dusky shales weathering buff—upper beds sandy and cherty, ...	60 feet.

Pre-meridian.		
Limestone—Encrinal in lower part, with various fossils, chiefly *corals*,		140-150 feet.
Scalent.		
Scalent Limestone—thin bedded, blue, with *Cytherina alta*,		100 „
Scalent grey marls.—(*a*) Indicated in soil at Moore's Quarry above Lewisburg (about 300 feet thickness).		
(*b*) Blue shales alternating with thin limestone beds and thicker beds of black fissile slates (about 200 feet visible at Shoemaker's Mill on Muncy Creek).		
(*c*) Grey marls of usual type, consisting of greenish and bluish marls, with occasional slaty purple or blue bands, and alternating flaggy argillaceous limestone, some beds of which are 20 or 30 feet thick.		
(*d*) Also blood-spotted shale—at point one mile below Milton, W. side of river—1100 feet.		
Total thickness of grey marls,		1600 „
Scalent variegated marls—alternation of red and green shale at Muncy Bridge,		20 „
Surgent.		
Surgent red shale—usual characters,		350 „
Surgent upper calcareous shale,		230 „
(*a*) Grey and greenish shale,	40 feet.	
(*b*) Limestone, with minute *Beyrichia, Calamopora, Atrypa, Cytherina, Avicula*, &c.	65 „	
(*c*) Greenish and buff slates,	65 „	
(*d*) Alternating slates and ferruginous limestone beds, with 4 or 5 beds of impure ore, the fossiliferous ferruginous beds from 4 inches to 2 feet thick, usual fossils of ore,	60 „	
Surgent lower calcareous shale—5 miles below Jersey Shore,		110 „
Greenish shale with sandy calcareous bands, containing *Agnostis Hemicripterus*, and a small branching fucoid.		
Surgent upper slate—branching fucoids,		} 700 „
Surgent iron-sandstone—contains an ore bed—position and thickness not ascertained,		}
Surgent lower slate,		}

SURGENT SLATES.

The Surgent lower and upper slates, and their included Iron-sandstone, occupy the N.W. flank of the Bald Eagle Mountain under a thickness of not less than 700 feet. These three formations all wear very nearly the characters which they possess at Danville. The slates are fissile and of a greenish-yellow colour, becoming brown and chocolate-coloured by exposure. Perhaps they are less sandy than in Montour Ridge. Their thickness is about the same as in that belt, or perhaps a little less ; the Clinton fucoid, or *Buthotrephis gracilis*, is confined to the upper slate. The Surgent iron-sandstone is a less important formation in this part of the belt than where the anticlinal of the North Branch of the Susquehanna lifts it to the day at Danville, but, as we shall presently see, it augments in its course towards Maryland. The silicious iron-ore (block ore of Danville) is discoverable in several places ; indeed, it is very generally developed in this stratum at its outcrop, high on the slope of the Bald Eagle Mountain. Specimens of the ore may be occasionally met with having all the features of that of Danville ; but it was impossible, at the time of our examinations, to determine the true dimensions of the layer, or the permanency of its quality, throughout a considerable length of outcrop, except in one or two neighbourhoods, to be mentioned. It merits a closer investigation on the part of proprietors than it has received. At the bend of the Susquehanna, a few miles below Jersey Shore, where the river washes the very foot of the mountain, fragments of the ore are to be seen, of such size as to indicate this as one of the localities deserving a more thorough examination.

Howard Furnace.—Near Howard Furnace the "block ore" has been successfully reached and mined on the N.W. slope of the Bald Eagle Mountain by the proprietors of Howard Ironworks. Its outcrop is more than half-way towards the summit of the ridge. The strata enclosing it dip 70° to N. 30° W., and the ore-bed lies about 60 yards S.E., or further in the mountain than the fossiliferous ore, which has likewise been discovered here, and regularly mined to a small extent. The block-ore, when seen in 1852, was 22 inches thick, and the ore was moderately rich, appearing to contain about 28 per cent of iron. The Iron-sandstone, the usual accompaniment of the block ore, outcrops in some places in this vicinity high on the mountain. The Ore-sandstone is apparently altogether wanting here, unless a few thin bands of grey sandstone in the overlying slates may represent it.

The total thickness of the whole slate group, with the included Iron-sandstone, is at this place probably 600 feet. Both the Surgent lower and upper slates decline in thickness as they range S.W., while the included Iron-sandstone augments.

SURGENT ORE-SHALES.

This group, containing the fossiliferous iron-ore, seems to be entirely deficient in the grey calcareous sandstone which so generally serves to mark approximately the position of the ore. Further S.W. along the belt the Ore-sandstone reappears, and in Bedford County assumes a very important thickness, and produces a marked feature in the topography.

The Surgent Lower Ore-Shale, viewed as commencing in the ascending order with the first introduction of calcareous and true limestone layers abounding in fossils, has a thickness in the vicinity of Jersey Shore, where it is well exposed, of about 110 feet. It contains the small branching plant, *Buthotrephis gracilis,* also *Beyrichia, Hemicripterus,* and other characteristic fossils.

It may be defined as a greenish calcareous shale, with many calcareous and sandy fossiliferous bands, and a few beds of ferruginous limestone graduating towards impure fossiliferous iron-ore.

The Surgent Upper Ore-Shale is a much larger subdivision than the last described, being in the neighbourhood of Jersey Shore not less than 230 feet thick, and there divisible into four subordinate members.

1. The lowest of these, which is about 10 feet in thickness, consists of greenish shale and slate, with about 8 or 10 thin beds of fossiliferous ferruginous limestone, four or five of which approximate in their composition to the iron ore. These hard bands are from 4 inches to 2 feet thick, but the richer layers of ore are only 4 inches thick each. The usual fossils of the ore group abound in this subdivision.

2. Succeeding the foregoing alternation is a more uniform division, composed of greenish and buff-coloured slates, with some fossils. This portion measures 65 feet.

3. A limestone stratum about 60 or 65 feet thick is next met with. It contains, between beds of argillaceous limestone, thin layers of shale. Its fossils are those everywhere else seen on the corresponding parallel in the formation, namely, *Beyrichia seminalis,* perhaps its most characteristic fossil; also *Cytherina alta, Atrypa lacunosa, Calamopora,* &c. This rock has at Dan-

ville a thickness of only 15 feet, it therefore expands in its course North-westward. It is a very continuous stratum, and is to be recognised in the formation throughout this entire belt.

Upon the limestone rests a grey and greenish shale, with some of the same species of fossils. This stratum measures about 40 feet, and terminates at the base of the Surgent red marl or shale.

Traced towards the S.W. along the base or lower slope of the Bald Eagle Mountain, and its continuation, both the Surgent lower and upper shales are seen gradually to decline in thickness, until, at the Potomac, the upper of these formations is only a very few feet in size. The ferruginous layers, sometimes sufficiently developed to constitute a useful iron-ore, possess in certain localities two or three times the dimensions they exhibit between Muncy and Jersey Shore. As in other belts further to the S.E. the iron ore occasionally belongs to the shale below the Ore-sandstone, and elsewhere to that above it, as one or other of the fossiliferous layers chances to be sufficiently charged with the peroxide of iron. In Bedford and Blair counties the ore is thick enough, in many localities, to be mined, where the conditions of the outcrop are favourable as respects its softness or richness in iron, and its freedom from excess of lime.

SURGENT AND SCALENT MARLS.

The Surgent Red Shale or marl preserves throughout the N.E. part of our present belt, as the vertical column shows, the usual characters and average thickness exhibited in the regions of the Juniata and Susquehanna. It contains few or no fossils, and is an argillaceous sandy red marl. Its ordinary colour is a rather dull brick red ; some portions are calcareous. The thickness of the stratum along the foot of the Bald Eagle Mountain from Muncy to Lockhaven is about 350 feet. Passing through Blair and Bedford counties it grows more sandy, but the mass contracts, and at the Potomac, in the vicinity of Cumberland, it is no longer perceptible.

The Scalent Variegated Marls are well exposed in the vicinity of Pennsborough or Muncy Town, where the stratum is composed of the usual alternation of red and green calcareous shales or marls. In this neighbourhood the mass is only 20 feet thick, and it continues thin for a great distance towards the S.W. ; but in Blair County we meet with it considerably more expanded. In passing through Bedford County into Maryland it again declines, and near Cumberland, on the Potomac, scarcely a trace of the formation is to be seen.

The Scalent Grey Marls have a much greater expansion than the stratum just described, and are traceable without interruption to the Potomac, but with a diminishing thickness, and lessening diversity of composition. They are distinctly exposed to view on Muncy Creek near Shoemaker's Mills, where they consist of bluish and greenish marls alternating with thin black argillaceous limestone, and in the upper part with beds or layers of fissile slate. At this end of the belt the whole formation measures nearly 1000 feet. Some of the beds of impure limestone are of considerable size. Many of these layers, especially in the lower part of the mass, are highly magnesian in their composition, and would produce an excellent hydraulic cement. The cement rocks quarried at Cumberland, on the Potomac, are in the inferior portion of this stratum. Where the N.W. outcrop crosses Blair and Bedford the grey marls still retain an expansion of several hundred feet, and the formation, though somewhat reduced at the Potomac, is even there in great force. Almost the only organic remains which it contains are the *Cytherina alta* and the *Beyrichia seminalis*, the most common perhaps of the Surgent fossils also. Indeed, it is doubtful if the two groups, the Scalent marls and the Surgent shales, are palæontologically separable.

Scalent Limestone.—This rock, under its ordinary type of a thinly-bedded light-blue limestone, with its distinctive fossil, the *Cytherina alta,* is plainly recognisable along the whole of the narrow belt of country of which I am now treating. Its destitution of corals, encrini, and several species of shells, abundant in the immediately overlying Pre-meridian limestone, will enable any observer, even without a critical knowledge of fossils, to separate it from that formation.

Thickness.—The inferior layers are argillaceous and magnesian, and are fitted for conversion into a hydraulic cement. Between Muncy and Jersey Shore this rock measures from 40 to 60 feet in thickness, and is therefore less exposed than in the region of Milton and Lewisburg on the S.E., where is dimensions are at least 100 feet. Proceeding along the belt it increases in its mass, and embraces more chert. In Blair and Bedford the rock is in many places more than 200 feet thick, and on the Potomac not less than 250 feet. It almost everywhere constitutes a thicker stratum than the Pre-meridian limestone uniformly in contact with it, but which, from its greater hardness, and higher position in the crests of the limestone ridges, seems to be the most important rock of the two.

PRE-MERIDIAN SERIES.

The Pre-meridian Limestone is nowhere largely developed in the N.W. part of the belt of country under review.

Thickness.—From Muncy to Milestown its thickness varies from 20 to perhaps 50 feet. It is for the most part a rough rock in massive layers, is often cherty, and always full of fossils, the fragments of crinoides, &c.; in the lower beds, and in the middle and upper ones, occur corals and shells. Traced through Blair and Bedford the stratum enlarges, and at the Potomac near Cumberland it is about 200 feet thick; while at Frankstown its dimensions are 135 feet.

MERIDIAN SERIES.

Thickness, &c.—The *Meridian slates,* like the Pre-meridian limestone, seem to expand in thickness in their progress S.W.; for in the region between Muncy and Lockhaven, the whole mass is rarely 50 feet thick; while at Frankstown the entire formation measures 170 feet. It everywhere consists of the same two strata recognisable in the vicinity of Montour Ridge, the lower a dark, ash-coloured, and black slate, with few or no fossils, the upper an ashy-grey, calcareous, and sandy rock, very sandy and porous at the weathered surfaces, and graduating upwards into the coarser Meridian sandstone. This upper member contains, at Frankstown and elsewhere, several species of organic remains not met with in the overlying Meridian sandstone.

The higher beds are often mingled with chert.

The Meridian Sandstone is very imperfectly developed in the N.E. part of the belt, but it augments in its course towards the S.W., being thick enough in the Bald Eagle Valley to form with the Pre-meridian limestone a low ridge. It is still thicker in Blair and Bedford, measuring at Frankstown, where the whole series may be readily studied, about 150 feet. At this locality it shows its North-western type, which is that of a very calcareous sandstone, internally compact and blue, but externally crumbly, yellow, and sandy, from the loss of its carbonate of lime. It contains the *Dethyris* (*Spirifer*) *arenosa,* the *Atrypa unguiformis,* and other common fossils of the formation, besides a profusion of a small species of *Cyathaphyllum.* Approaching the Potomac, this rock appears again to decline in bulk.

CADENT AND VERGENT SERIES.

Throughout this entire long belt at the foot of the Alleghany Mountain, the Cadent and Vergent rocks are greatly expanded. The five formations which make up the series, as developed in Pennsylvania, are all distinctly recognisable in the N.E. portions of the tract, one only, the Cadent lower shales, seeming to thin away in approaching the S. side of the State. The reader will receive a sufficiently exact idea of the N.E. type of the several formations from the vertical column, representing these rocks as they occur on the W. Branch of the Susquehanna opposite Whitedeer Valley. Between Muncy and Lockhaven the several Cadent and Vergent strata are seen very nearly as they are exhibited in that column, with the exception of the Cadent lower shale.

Cadent Lower Black Slate.—In the long tract from Muncy to the Potomac the Cadent lower black slate maintains everywhere its character of a thinly-laminated fissile black slate, coloured by carbonaceous matter, and recognisable by the *Orthis limitaris.* The lower division of the mass contains in the N.E. part of the belt no argillaceous and ferruginous limestone, such as characterises it at Selinsgrove and in Franklin and Bedford, but in their place large lenticular masses or cakes of blue limestone and septaria; and as we advance S.W. these layers become continuous and more abundant, though the whole formation declines somewhat in thickness, measuring about 600 feet at Muncy, but only 350 feet at Frankstown, and at the Potomac a little more than 400 feet.

This rock, the *Cadent Olive Shale,* displays in the district before us a more considerable deviation from its S.E. type than is exhibited by any of the other members of the series. In the Muncy Hills it is a hard, blue, calcareous, and sandy shale, easily recognisable by its fossils, the *Microdon bellastriata, Delthyris mucronata, Fucoides velum,* &c.; but further towards the N.W., as at Lockhaven, it has become much more calcareous, and has also acquired a more argillaceous aspect. It is there a dark bluish-grey sandy shale, passing downwards into an impure argillaceous limestone and calcareous shale, with small balls of sulphate of iron.

Thickness.—Between Frankstown and the foot of the Lock Mountain this formation is about 400 feet thick, but none of its fossils could be recognised on the Portage Railroad, though the two adjoining rocks are there well exhibited. That it does not extend to the Potomac at Cumberland is certain, from careful investigation, and we may consider it as very thin everywhere to the S.W. of the meridian of Hollidaysburg.

The Cadent Upper Black Slate.—Throughout this belt the Cadent upper slate is a bluish-black fissile slate, sometimes containing apparently very minutely-divided mica. A minute, saggitate, leaflike fossil is perhaps its most characteristic form among the organic remains.

Thickness.—This stratum is between 250 and 300 feet thick in the Muncy Hills, and the N.E. part of our present line of outcrop. In the vicinity of Frankstown it is somewhat thicker, and at the Potomac, near Cumberland, not less than 700 feet.

The Vergent Flags.—These rocks are admirably exposed on the Susquehanna, at its passage through the Muncy Hills, and at Penny Hill. They are likewise distinctly revealed to view in the cove near Frankstown, and on the Potomac, a few miles below Cumberland. Along the whole base of the Alleghany Mountain this stratum has caused, by its relative hardness, a broken terrace or chain of hills.

Thickness.—Its thickness is apparently very constant, being on the Susquehanna about 1200 feet; at Hollidaysburg a little more, and at the Potomac 1600 feet. The formation consists, throughout this line, of a fine-grained dark-grey sandstone in moderately thin layers, in constant alternation with thin bands of blue clay-shale. The flaggy sandstones abound most in the middle of the mass. A few large *Fucoids* or marine plants, and much more rarely, a small species of *Nucula*, are the chief or only fossils.

The Vergent Shales.—This great formation preserves everywhere along the foot of the Alleghany Mountain its usual type, which is that of a greyish olive-coloured and blue shale, imbedding grey sandstones. In the portion next the Ponent series it contains, in a thickness of several hundred feet, an alternation of grey and red sandstones. Throughout this line of outcrop the formation presents its usual fossils, as *Avicula chemungensis, Inoceramus damnoniensis*, &c.

Thickness.—It is fairly exhibited in the Portage Railroad, on the level between the inclined planes, Nos. 9 and 10, where the total thickness of the mass cannot be less than 2200 feet, which is about its average bulk along the whole line. On the Potomac, some miles E. of Cumberland, the thickness is 2100 feet.

Iron Ore.—It is in the upper part of this formation, among the alternating red and grey beds, that the brown sandy granular iron-ore of Larry's and Lycoming creeks exists.

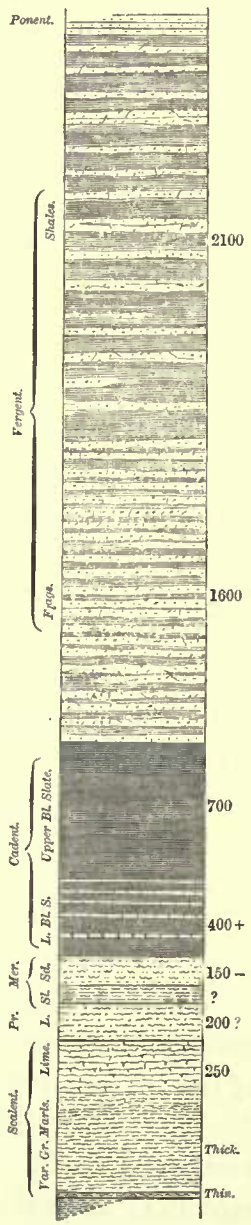

Fig. 108.—Strata near Cumberland, on the Potomac River.

PONENT SERIES.

Thickness, &c.—The *Ponent Red Sandstones and Shales* form along our whole line a large part of the escarpment of the Alleghany Mountain, being surmounted in the upper portion of the plateau by the Vespertine sandstone or conglomerate. This formation is more argillaceous than in the districts further E. and S.E., and is materially reduced in bulk. Its average thickness in the Alleghany Mountain is about 2000 feet.

The natural sections exposed along the valley of the Potomac River offer the only good opportunity S. of the neighbourhood of Hollidaysburg for instituting exact measurements of the several subdivisions of the Surgent and Scalent, Pre-meridian, Meridian, and Cadent and Vergent series, and for critically tracing the vertical distribution of their organic remains. I have, therefore, deemed it expedient to illustrate the stratification of the S. part of the belt we are to examine in detail, by a section in columnar form, compiled from observations made by Professor William B. Rogers and myself in the vicinity of Cumberland. (See Columnar Section, fig 108.)

CHAPTER II.

LEVANT, SURGENT, SCALENT, PRE-MERIDIAN, AND MERIDIAN SERIES.

Along the Valleys of the West Branch and Bald Eagle, from Muncy to Milesburg.—Where Muncy Creek flows into the river, it cuts down through the calcareous Surgent ore-shales, which are exposed both on the creek and the river-bank. They consist of olive shales below, and calcareous layers above. On the creek they are succeeded by the overlying Surgent red shale, exposed beyond the bridge one mile above the village, then by the Surgent variegated shales, and finally by buff-coloured Scalent limestone or cement layers. The resemblance between these rocks and those at Lewisburg will be at once detected. They extend for 50 yards along the creek, and dip 25° nearly E. The Bald Eagle axis prolonged would cross the creek about 600 yards above its mouth.

The olive shales exposed for one mile along the river, disappear beneath it, with a dip of 30° N. The calcareous layers, which in their lower portion alternate with layers of slate, but become more solid upwards, form, at Carpenter's Run, natural exposures of curved and twisted massive strata, traversed with veins of calc-spar. These continue for three-fourths of a mile. At the Quarry this rock contains a great profusion of fossils, so that when polished for mouth-pieces, it is elegantly shaded by the imbedded shells and encrinites.

The Surgent Red Shales form the sides of the ravine of Carpenter's Run over the calcareous layers. The limestone bands are but little infiltrated with iron, so that iron ore is not present in the series here. One of the most Eastern outcrops along this line of the newest member of the series, the Scalent (cement) limestone is at a quarry one-fourth of a mile E. of the village of Pennsborough, where the strata vary from 4 inches to 2 feet in thickness, dipping 35° toward the S.

At the end of Limestone Ridge, 1¼ miles N. of Muncy Hills, is a large quarry ; the limestone pure, and dipping N. ; other quarries are on the same range traced W., as at D. Gottman's, N.W. of Pennsborough.

For several miles W. the river, with its bed of gravel, covers the Surgent series, but in the canal, cutting half a mile E. of the village, it is struck in a well. It is exposed one mile E. of the village on Mr Shoemaker's farm ; at the bridge below the mill, and at the mill-dam, the dip being S. 70° E. 30°. Here the rocks are interstratified dark-blue slates and limestones ; slates containing shells, some laminated, others breaking into rhombs, and hard silicious limestone, containing large shells.

The curved and thick calcareous strata appear again 4½ miles E. of the Loyalsock, where they are interbedded with thin slates, and traversed by veins of spar.

One mile W. of this the Surgent red shales are exposed along the canal, and in a transverse ravine at the Lock, and ascending this ravine the Surgent variegated shales are seen overlying the red shale, and still further up, a quarry at the main road gives a view of the Scalent (cement) limestone. No exposures occur between this and Loyalsock.

Fine exposures of the Scalent (cement) limestone occur 6 miles E. of Williamsport, dipping N. 5° E. 30° to 35° in the quarries of Messrs Hall, and again at Davis' Tavern. The strata are massive, yield a fine lime, and contain few fossils. W. of Loyalsock Creek are also fine exposures, both quarried and natural, and some of the quarries are of great dimensions, but no fossils are discoverable.

Hence to the W. side of Pine Creek this latest deposit of the Surgent and Scalent age is nowhere seen.

The formations of the Levant series above the Levant white sandstone are not visible in either of the gaps which open through the Bald Eagle Mountain at Loyalsock Creek, at Williamsport, and at Newberry; but when the river, after leaving the mountain at the mouth of the Quinoschockony (Quemashohogue), and crossing into the Cadent and Vergent hills to the N., returns to the mountain again, 4 miles E. of Jersey Shore, it presents the following exposition of these Levant formations :—

1. Surgent red shale, a few feet.
2. Olive shales of considerable thickness.
3. Limestone, granular, massive, interstratified with highly fossiliferous slate.
4. Shale, dark, loose, highly fossiliferous.
5. Limestone, full of fossils, some of the layers ferruginous, and forming, where weathered, a good ore, but having the aspect of a pure limestone within.
6. Olive shales.
7. Limestone, two layers of which are ferriferous, but hard, interstratified with pure limestone, containing with the others multitudes of shells, corals, encrini, and trilobites.
8. Buff shales, loose in structure, and very fossiliferous.
9. Olive shales, thinly stratified.
10. Reddish stratum, sometimes compact.
11. Olive shales, with thin dark silicious layers breaking into rhombs, containing some white shells, but full of an obscure fucoid.
12. Brownish laminated slate, without fossils, 25 paces.
13. Olive slate, covered with soil at the bank of the river—dip 35° N.

Four of these calcareous beds appear to be somewhat ferriferous, but are too little impregnated to encourage mining them for ore. They are used for burning and building.

One mile W. of the above locality the superficial matter has slipped from the mountain into the river, laying bare a face of Levant white sandstone 25 yards square, with a dip of 45° to the N.W.; and further W. is an exposure of some superincumbent rocks full of fucoids.

At Jersey Shore, the turnpike cuttings at the entrance of the Nippenose Valley Gap expose the Surgent olive shales, together with the red shales, resting low down upon the slope of the mountain.

The fossiliferous slates and limestone layers occur on the edge of the creek a few hundred yards further W., at the limekiln in the woods.

Where the river again sweeps the base of the mountain S. of Jersey Shore, long exposures exist, beginning 400 yards above the mouth of Nippenose Creek; here are the Surgent variegated shales, then Surgent red shales, 150 yards exposed, dip 35° N., resting upon Surgent calcareous layers; layers from 4 inches to 3 feet thick, contorted, traversed by veins of spar, and weathering granular or speckled, from the innumerable minute black discs of encrinites, &c., appearing on a ground of lead blue. These are exposed for 50 yards along the river. In their lower portion they alternate with blackish or dark olive slates, which in turn alternate with reddish and thin dark-brown shale, weathering in square plates, followed by green and then yellowish slate; the whole exposure terminating opposite Pine Creek mouth. No trace of ferriferous rocks could be discovered at this exposure of the Surgent ore strata.

No exposures of middle Surgent rocks can occur in the next 7 miles, for the river has its course upon them in the direction of their strike, nor are any observed when it leaves the mountain and approaches it again below and above Chatham Run. A flat, 6½ miles long, and 2 miles wide at the broadest part, borders the mountain in the interval. But upon Pine Creek we meet very satisfactory exposures of the Scalent (cement) limestone, together with the overlying Pre-meridian limestone and Meridian sandstone. The accompanying diagram (fig. 109) looking E. at the wall of rock upon the left bank of the creek, before it enters the Susquehanna, will explain the stratification.

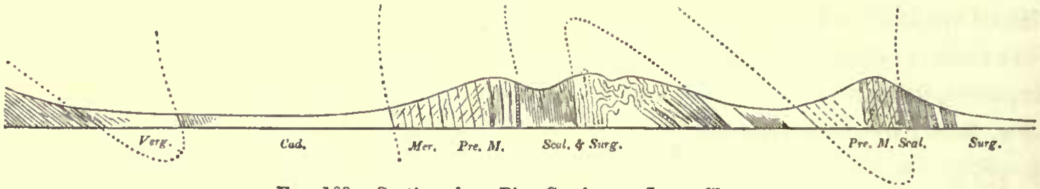

Fig. 109.—Section along Pine Creek near Jersey Shore.

One mile from the river, in the bluff end of a ridge, are seen thin beds of limestone, alternating with sandstone, and succeeded by thick irregular strata of grey or nearly white calcareous sandstone, full of the large characteristic fossils of the Scalent and Pre-meridian and Meridian series, and interstratified with very fossiliferous limestones. These are exposed in vertical position for 50 yards along the bank. A hollow separates this hill from a similar one just N. of it in the cliffs, at the end of which, and 200 yards from the hollow, we have bold ledges of chert and limestone, dipping S. 35° E., full of shells and encrinites. Other similar ledges succeed for more than 100 yards along the creek, and are strangely contorted in the cliffs above. Here a cave exists 25 yards in length, 3 feet high at the mouth, and enlarging to 15 or 20 feet in the interior.

Still further up the creek we see vertical alternating layers of pure grey chert and calcareous sandstone, becoming more fossiliferous and silicious upwards, and passing into pure sandstone, with the fossil cavities characteristic of the Pre-meridian and Meridian series. These form a third bold knob, on the S. side of which is a stratum of pure fossiliferous limestone, and on the N. the Meridian sandstones with a very steep S. dip, thus underlying the Scalent rocks, as shown in the diagram.

Half a mile N. of the last exposure, the olive slates appear with a S. dip. We have here therefore a double anticlinal, repeating the three formations of the Pre-meridian and Meridian series; probably the same axis which projected W. into the triangular Pine Creek Bottom, brings up the cherty limestone on the flank of the hill at the N. side of Mr J. Hamilton's farm. The layers are very flinty above, but less silicious below, about 10 feet being visible.

In Bailey's Quarry, 400 yards E. of Pine Creek, pure limestones alternate with more argillaceous layers, containing a great profusion of Pre-meridian fossils: dip 40° S. 35°. E. This is in the S. hill.

McMany's Quarry in the N. hill, in a line with the contorted strata on the creek, exposes an extremely fetid limestone, crowded with beautiful corals: dip S. 25° E.

These two hills gradually decline towards the E., and not a trace of their strata is to be seen at Jersey Shore, neither do they pass the creek W. An extensive triangular bottom occupies all the space between the river and the creek. Their next exposure is at Flemington, in the Bald Eagle Creek Valley.

West of the mouth of the Bald Eagle Creek 800 yards, the Surgent ore calcareous layers are again exposed and quarried. They show the same characteristics, of a dark hue, mixtures of spar and alternations of slate, and of corals and other fossils. They are here close to the base of the mountain, which in this place is higher and of more regular aspect than further E.: they dip 35° N., a little E.

In Fleming's Gap, $1\frac{1}{2}$ miles W., the olive slates appear, dipping 30° N., and again at the Millhall Gap, where, on the E. side above the furnace, the red shales are seen to form the mountain slope. Higher up, the Surgent ore-shales or calcareous strata are quarried and burnt for lime. These are exposed 200 feet above the creek.

Successful search for a ferriferous layer has been made at this gap, but it seems to be too refractory to be worth working, while the softer pipe-ores are so accessible in the neighbouring Nittany Valley. From this point S.W., the slope of the Bald Eagle Mountain is permitted to extend further into the valley, the broad river being replaced by the narrow Bald Eagle Creek. Pines cover the upper third of it, and oaks and chestnuts all the rest. The line of junction runs along a terrace formed by the upper slates, the Iron-sandstone and the lower slates of the series reposing against the white sandstone which forms the crest.

FIG. 110.—Sketch showing different vegetation upon different rocks in the Bald Eagle Mountain.

Exposures of the soft upper Scalent rocks are nowhere to be seen, even in such clefts as Morrison's Gap near the mouth of Beach Creek, but they are everywhere to be sought for under the blue stones and fallen timber that cover the side of the mountain.

North-west of Millhall $1\frac{1}{2}$ miles, and one mile from the Bald Eagle Mountain at G. Brown's, there is a quarry of the Scalent (cement) limestone, here a grey, crystalline, massive formation. It is adjoined by a darker, less crystalline, compact, smoothly fracturing, blue and very fossiliferous Pre-meridian limestone.

The hill containing these rocks runs along the base of the Cadent olive slate-hills that occupy the middle region of the valley.

West of this locality 450 yards, the canal has opened a section 400 yards long, reading as follows:—

1. Limestone, dark, interstratified with seams of shale, and containing shells and other fossils.
2. Yellow slaty limestone.
3. Yellowish shale.
4. Massive limestone, which is fetid when struck, containing shells and corals, dipping 35° N.N.W., exposed for 200 yards along the canal.
5. Loose ash-coloured calcareous fossiliferous rock.
6. Thin shales. These belong to the Surgent marls beneath the Scalent limestone; the latter formation composes the lower half of this exposure. The same limestone is seen $1\frac{1}{4}$ and $2\frac{1}{4}$ miles W. of this locality; on Plunket's Run, 200 yards from the road; on Marsh Creek, same distance from the road; on a run 2 miles W. of Marsh Creek, and on the canal at Howard. Dip everywhere N.N.W.

North-west of Millhall, a high ridge, composed of Surgent, Scalent, Pre-meridian and Meridian rocks, extends W. to Beach Creek, and exhibits in its ravines several sections of strata above those just described, which appear along its S. base. Beach Creek makes a wide breach in in this ridge in connection with Marsh Creek. W. of the latter it again appears with the Cadent black-slate formation on its N. slope. The Meridian sandstone forms its crest, covered by a conspicuous line of pine woods. It terminates at Howard Furnace, where, for one mile, the valley is a flat, from Bald Eagle Mountain to the olive slate hills, being denuded thus in front of the Howard Furnace Gap. W. of the flat the slate hills are seen to sweep round it, the Cadent black slates first rising; then the Meridian sandstone; lastly the Pre-meridian and Scalent limestones on the S. slope washed by the creek.

The chert layers, full of fossils, are finely exposed on Green's Run, 2 miles W. of Howard Furnace, while the limestones form a cliff along the S. slope as far as Bartlett's Run, where there is a good exposure.

At Howard Furnace, openings have been made near the top of the mountain upon two beds of ore, 50 yards apart, dipping 80° to the N.N.W. The lower ore, outcropping higher upon the mountain, is a non-fossiliferous, very ferruginous sandstone, 16 inches thick; the upper ore a fossiliferous ferruginous limestone, from 6 to 10 inches thick, with slate above and below it. It had not at the time of examination proved available at the furnaces. At Eagle Furnace Gap, 7 miles S.W. of Howard, the Scalent (cement) limestone appears upon the W. side at the base of the mountain, and up the slope are seen the outcrops, first of the red shale and then of the Ore-limestone shales, very near the top of the mountain.

From the gap E. of Eagle Furnace, to the Milesburg Gap west of it, the Bald Eagle Mountain is very irregular in height, its crest curved into a succession of summits, and its slope abraded and scooped by violent denuding action. Pine woods and fragmentary matter cover it from summit to base.

The next exposure of the Scalent (cement) and Pre-meridian limestones is at the Old Eagle Furnace, 200 yards up the unusually long and gentle ascent of the mountain. On the W. side of the gap, the limestone strata are seen dipping 45° W. 70° N. (See Section, fig. 111.)

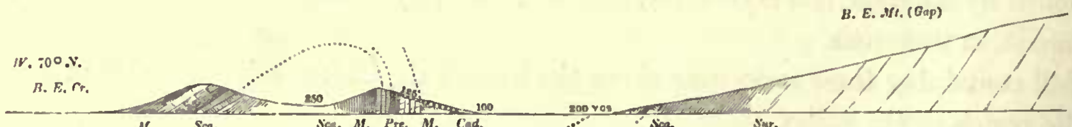

FIG. 111.—Section at Eagle Furnace, Bald Eagle Creek Valley.

They appear again in vertical layers on the summit of the short hill opposite the foot of the mountain, and again, dipping 30° N. 30° W., in the face of the next little ridge, at the N. foot of which flows the creek. Thus we have a synclinal and an anticlinal flexure, in the former of which, 100 yards N. of the foot of the mountain, is a little patch of the Cadent black slate, the sole relic of that formation. The Meridian sandstone lies in fragments, with great deposits of sand, on the S. slope of the first, and forms the crest of the second little ridge.

The Pre-meridian or upper division of the limestone is filled with curved and delicately-formed corals, visible only on weathered surfaces.

Nearly 2 miles E. of Milesburg, the silicious Pre-meridian limestone appears upon the N. side

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of the creek, dipping 35° N. 18° W., and above it is seen the Meridian sandstone. It is also quarried back of Milesburg, dipping 30° in a slight elevation at the foot of the mountain. At another exposure on the W. side of the creek, the layers stand almost vertical; and it is seen again a quarter of a mile to the N.

In the Milesburg Gap, the Surgent olive slates appear in a nearly vertical position. On the S.W. side of the Gap, the red and buff shales are exposed, but no limestone is visible. The ore, obtained after much digging, was found to be of no great value. A section through the mountain, which here as elsewhere is double, gives the following characters for the Levant series:—

1. Levant white sandstones, 450 feet.

2. Levant red sandstone, argillaceous, thin-bedded, grey and red sandstones, alternating with quartzose red, grey, and greenish shales, and without conglomerate. In the upper part, a vertical stem-like form, like an irregular Scolithus. Thickness, 500 feet.

3. Levant grey sandstone, consisting of (*a*) greenish-grey slightly micaceous sandstone, with ochreous specks; thin layers of fissile green slate, perhaps belonging properly to the red sandstone, 380 feet: (*b*) hard grey sandstone, forming a terrace on the mountain towards the S.W., not conglomeritic, full of yellow specks, 170 feet.

MERIDIAN SERIES.

The Pre-meridian limestone, and, occasionally, the Meridian slates and sandstone, have in the preceding Section been described along with that of the Scalent series, the two being adjacent, and intimately connected. It remains for us to trace the Meridian sandstone formation Westward from Muncy. Along this valley it is a thin mass, and may be studied in the fields S. of the village, where its fragments, full of fossils, strew the surface. It is probably in place beside the road, half a mile E. of the village, and its fragments are abundant at Muncy Hills. It again crops out at Hicksville, 3 miles N.W. of Muncy, near the road, where it abounds in casts of shells.

It has been already described as it occurs at Pine Creek and at Flemington. It forms the sustaining mass of the ridge, which, commencing 5 miles W. of the Susquehanna, is washed on the S. by the Bald Eagle Creek, and supports the Cadent slates on its Northern slope. This formation may be seen along Plunket's Run, dipping beyond the limestone 30° N. 14° W. Here its strata are massive, and thronged with large and unusually beautiful casts of shells. The banks of Marsh Creek are thickly strewn with fragments from this formation.

Green's Run cleaves the next continuous portion of the ridge, but without giving exposures of the sandstone, though fragments strew the top of the ridge towards the W., the disintegrated sand from which, flowing down ravines on the N. slope, has collected in a large deposit through which the road has been made.

The most massive strata of the formation appear upon Bullet's Run, where the ridge formed by this sandstone terminates. Thence onward the formation is traceable by a lower ridge, covered with its blocks, but offering no exposures, and in its turn terminating at the next bend of the Bald Eagle Creek.

The Meridian sandstone is next exposed in the end of a low ridge, 3 miles S. of Eagle Forge.

Loose blocks, 5 feet square, cover the continuation of this ridge beyond the little run which descends from the Eagle Furnace Gap.

The sandstone exposed for 300 yards, and full of fossil casts, is again seen 2 miles E., and also a short distance W. of Milesburg, on the S. side of the creek.

CHAPTER III.

CADENT AND VERGENT SERIES FROM MUNCY TO MILESBURG.

THE Cadent and Vergent strata are finely exposed at the end of the Muncy Hills, in a series of cliffs 250 or 300 feet high. These rocks are in part loose and argillaceous, in part compact and arenaceous, and include some fossils. The middle line of the synclinal trough crosses the river half a mile below the Dam, above which we have exposed, for 1200 yards, gently South-dipping, massive, dark olive argillaceous strata, in which fossils are extremely rare. Below the Muncy Lock the Cadent black slates are exposed for 400 yards, dipping nearly 35° S. Their weathered surfaces are whitened by an efflorescence of sulphate of iron and alumina. Opposite the Lock, in the bank of the river, these slates are seen to include calcareous layers.

Numerous exposures of South-dipping Cadent and Vergent rocks are visible along the N. escarpment of the Muncy Hills, washed by the little Muncy Creek, until, for miles E. of Muncy, that escarpment sweeps round N. and W. Beyond this bend, for more than 20 miles, the country is occupied by Cadent and Vergent rocks. They form a table-land of rounded hills, with gentle slopes and few exposures. A fine view of this bend of the hill may be had from an eminence 4 miles from Hughville, on the road to Williamsport.

The calcareous layers of the Cadent black slate of Muncy Creek, near Hughville, are exposed in the gorge, where they are blasted in square masses, full of shining specks of pyrites.

Ascending the Big Muncy Creek, and passing a single North-dipping exposure of slate, half a mile below Woodley's Mill, all the rocks of the Cadent, Vergent, and Ponent series are crossed in succession, dipping N. at angles varying between 55° and 15°. Exposures occur at intervals of many hundred yards, and often in cliffs of very considerable height, rising, as we go N., into mountains. The hills around Hunter's and Lewis's lakes consist of Ponent red and grey sandstone. At the outlet of the former are seen the Ponent red shales, and at the outlet of the latter, Vespertine conglomeritic sandstone. The hill on which the Lewis Lake Glassworks are built is covered with masses of coarse grey micaceous sandstone, from the weathering down of which the glass sand has originated.

Upon the Rock Run Hills, 90 rods from Taylor's Mill, is seen the outcrop of a limestone belonging to the Ponent rocks. It is a dark brecciated argillaceous limestone, effervescing freely with acids, and, where weathered, showing a pitted worm-eaten surface. It is a thick-bedded rock, one of the layers being 5 feet in thickness, and is pervaded by thin filaments of green carbonate of copper. As a source of lime, this stratum must become of great importance to the farmers of the secluded red sandstone valleys, at the base of the Alleghany Mountain. Fragments of this rock are strewn profusely over the Harding and Phillips farms at the S.W. base of the Bald Mountain.

In a deep gorge, S. of Muncy Creek, and one mile S.W. of Eagle Mountain, we meet with the copper diggings of Mr Phillips, in the alternating red and blue shales of the Ponent series. Along with thin flakes of the carbonate of copper, the shales contain impressions of ferns and reeds in great abundance, both the minerals and the fossils being more abundant in the blue shale than in the red. No valuable amount of ore has been, or is likely to be, found in this geological position.

West of the head-waters of Carpenter's Run on the high flat terrace, from the N. edge of which rises the Alleghany Mountain, coal has been sought for by diggings in a stratum of Ponent brown shale, 12 feet thick, and in beds of very pyritous black slate, filled with vegetable impressions, and which dip 15° or 20° N.E. Similar futile attempts to find coal have been made in a black slate, outcropping along the side, and at the end of a spur of the Alleghany escarpment, here composed of nearly horizontal Ponent strata.

In the section exposed along the W. side of the Loyalsock Creek, from the bridge near its mouth, through a distance of 8 miles, into the gorge of the Alleghany mountain, the formations referred to present themselves in the following order :—

Immediately above the bridge the Cadent black slates are seen in a thickness of at least 150 feet, alternately loose, shaly, and compact, and dipping at an angle of 40° towards the N. Northward of these, for several miles, we meet with exposures of olive slates and sandstones, which at length alternate with dark-brown and red rocks, near the base of the Ponent series. Still higher up the stream, at the distance of 5 miles above the mouth of the creek, a series of vertical beds make a sharp flexure in the olive argillaceous strata of the Cadent and Vergent series, here highly fossiliferous, and are followed towards the N. by an anticlinal in these rocks of comparatively gentle dips, extending into the Alleghany Mountain. These are seen in the overlying cliffs of massive red Ponent sandstone along the creek.

On Lycoming Creek, within half a mile of its mouth, we meet the Cadent black slate, with its calcareous layers near its base, followed, further up the creek, by the compact olive slates and sandstones of the next superior formation, of which some of the quarries, as that at Mahoopeny's, yield a fine, compact, bluish rock, so massive that many of the strata are as much as 4 feet in thickness. In the shaly partings between these beds are a few fossils. These strata are bent into a sharp and narrow anticlinal, on the N. side of which, at about 4½ miles from the mouth of the creek, we pass from the vertical olive sandstones to the adjacent red rocks at the base of the Ponent series, similarly inclined. These vergent rocks display themselves with a Southern dip, and arching over in a broad anticlinal, again descend at a point 3 miles further N., this interval in the section being occupied by the olive slates and sandstones of the subjacent series.

At John Kintel's, about 7 miles above the mouth of the creek, resting upon thick, red, argillaceous sandstone, on the crest of a little anticlinal flexure, there repose two layers, 3 feet thick, of coarse grey-and-reddish impure limestone, seemingly an irregular deposit of marine shells. Upon the limestone are olive shales, also a mere confused mass of fossil shells ; then a bluish-green slate, in thick beds ; then dark olive, and, finally, red shale.

North of the quarry exhibiting these rocks, the red fossiliferous ore has been found of good quality. It measures from 18 inches to 2 feet in thickness; and is covered, as upon Larry's Creek, by olive slates.

Indications of a remarkable dislocation are observed in the olive sandstones at the quarries first spoken of, $1\frac{1}{2}$ miles above the mouth of the Creek.

Few exposures of the Cadent and Vergent rocks occur on Pine Run, but on Larry's Creek we meet with a number which are of interest. This stream enters the Susquehanna just below Jersey Shore, and above the very remarkable and beautiful cliffs disclosed along the canal. A more striking natural section can scarcely be conceived than the one there presented of the Cadent and Vergent strata, continuously exposed.

An interesting group of flexures and contortions comes in view as we turn from the main road at the canal and creek bridges to ascend the right bank of the creek. These are in part pictured in the accompanying section.

FIG. 112.—Section of rocks on Larry's Creek, near the Susquehanna River.

Between Knox's Mill and the Forge are seen the alternations of red and olive rocks; red and yellow shales appear opposite the forge with a N. dip, they are covered by red argillaceous massive sandstone, and these again by olive slate opposite the sawmill. High on the end of a ridge are the deserted ore-drifts of the Farrandsville Furnace Company. Exposures of alternate red and grey sandstones occur along the creek until the high hills are reached, which, covered with angular debris of the Ponent series, and supporting a dense hemlock forest, announce our approach to the Alleghany escarpment.

The synclinal axis of Short Mountain crosses the creek about 4 miles from its mouth, and the Thom's Run anticlinal 2 miles higher up.

A sharp anticlinal axis ranges along the S. side of the Short Mountain, and issues upon Pine Creek below the forge. Two miles W. of Larry's Creek, in the valley of Canoe Run, the Vergent iron-ore has been opened in several places, with steep opposite dips. In the drifts upon the N. dip, the ferriferous bed is nearly vertical, and is 3 feet thick. The olive shales above and below the ore assume a chocolate brown as they approach the ore-bed, which forms a very regular seam. A band of slate, 2 or 3 inches thick, divides it in the middle. At another opening W. of these the ore is divided by 6 inches of slate into two beds of 18 inches and 6 inches respectively.

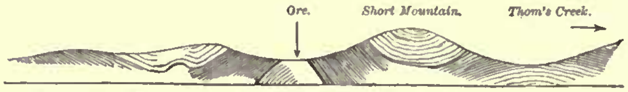

FIG. 113.—Section of Short Mountain synclinal, and anticlinal of Canoe Run, with Vergent iron-ore.

The same compact bluish-brown ore in olive shale has been opened upon a S. dip of 45° at Swartz, $1\frac{1}{2}$ miles N. of Jersey Shore. It is here 18 inches thick, accompanied by fossiliferous shales. It is again met with on a N. dip of 80°, about 3 miles N. of Jersey Shore.

Opposite Jersey Shore the Cadent and Vergent calcareous rocks appear, containing trilobites and other fossils in great profusion.

Near the mouth of Nippenose Creek, only 400 yards N. of the Surgent red shale before mentioned, the Cadent black slates are seen with a steep S. and almost vertical dip.

On Pine Creek the Cadent olive slates are finely exposed in mural precipices. They dip S. 30° E., and have a thickness, so far as exposed, of 250 feet.

A small anticlinal flexure occurs N. of this, and then at the forge a larger one with nearly vertical N. dips. This is succeeded by the synclinal of Short Mountain, exposing Ponent red shales, containing a fan-shaped fossil and alternating red and grey sandstones. The Thom's Run anticlinal, crossing 6 miles above the mouth of the stream at the sharp bend, brings up no lower rocks than the Ponent red shales.

W. of Pine Creek the Cadent olive shales reappear, forming a hill at Chatham's Run, and continue thence to the Susquehanna at Lockhaven. At Furguson's Mill they are seen dipping 30° N. 10° W.

The brown argillaceous iron-ore was met with in fragments on Mr H. Davis' land, half a mile distant from the base of the Alleghany Mountain, and one mile E. of the main branch of Chatham's Run. A ridge of Cadent and Vergent rocks, at its highest point almost equalling the Bald Eagle Mountain, ranges along the synclinal trough, which extends W. from Pine Creek between the Furnace axis at the S. base of the Short Mountain, and the little axis next S. of it, in which the Pre-meridian chert and limestone are brought to view.

On the Susquehanna River, half a mile N. of New Liberty, the blue pyritous calcareous layers of the Cadent series first make their appearance. Here the thick layers rest upon the thin, and are overlaid by black slates, whereas at Jersey Shore the thin layers are above the thick, and both are above the black slate. Thickness of the mass, about 100 feet; dip, 30° N.N.W.

The blue calcareous layers are again exposed above the Lockport Hotel, massive, and containing round nodules of pyrites overlaid by brown shale, and then olive shales upon the river.

On the W. side of the river, three-fourths of a mile above Lockhaven, commences a series of exposures, which is continued 1¼ miles towards the N., beginning with a dip of 20° N.; but the inclination increasing in steepness, they are sometimes vertical. At the base of the end of the first mountain the Ponent red sandstone appears with a N. dip, followed by red shale alternating with red sandstone, and then for half a mile up the dam by brown and massive grey micaceous sandstone, dipping steeply N.

Below Farrandsville a band of conglomerate forms the floor of the massive grey-sandstone cliffs which continue to characterise this valley for 30 miles above this point.

On comparing the section of North-dipping rocks thus presented with any of those already given along more eastern waters, we discern a great change in the geological structure of the Bald Eagle Valley. In the latter direction numerous axes produce alternating Northern and Southern dips, while here not a single anticlinal is to be detected.

West of the Susquehanna River at Lockport, the hills composed of the Cadent olive slate and sandstone, range along the valley in bolder and less broken chains, and from the steepening dips, and consequent contraction of the valley, approach the side of the Bald Eagle Mountain. Beach and Marsh creeks, making a wide breach in the more Southern line of hills, have here spread out a fertile bottom.

The Black slates and calcareous layers approximating to a pure limestone appear on Plunket's Creek. The Black slates show themselves again on Beach Creek, one mile above its mouth, dipping 30° N. 15° W. North of this exposure, about 500 yards, are seen the Cadent calcareous layers, dipping 25° N. 15° W.; and 400 yards still further N., begin exposures of dark blue slates alternating with brown, and succeeded by olive. These are overlaid by alternations of compact and soft, shaly, olive-coloured rocks, and these again by massive olive argillaceous sandstones, all dipping 30° N. 15° W.; the last exposure being at Quiggle's Mill.

Two miles above its mouth, Beach Creek cuts through a very lofty hill or mountain of

Cadent and Vergent and lower Ponent strata, separated from the true Alleghany Mountain by a small posterior valley, olive and grey sandstones dipping 25° N. 15° W.; and higher up the valley, compact olive slate, containing fucoids and shells, and grey micaceous sandstone, with a clean cubic fracture, form its base. Near the summit of the hill, in layers of Ponent red shale, unsuccessful diggings for the rich blue argillaceous ore have exposed some ore of another and worthless variety. This ore should also occur upon the creek at the knobs projecting Eastward from the little valley situated behind the hill.

Good grindstones have been quarried from the grey micaceous strata, 500 yards N. of the bottom of the Alleghany slope, dipping 25° N. 10° W., and exhibiting vegetable impressions and small quantities of carbonate of copper. Very rich specimens of the blue ore of Larry's Creek are said to have been obtained from the loose soil in uncovering this quarry, 15 miles from the mouth of Beach Creek. Red shale is exposed higher up the stream.

North of Howard Furnace, the Cadent olive slates dip 30° N.N.W. An immense hill towers above the cove, in which Asky's Run has its source; it is separated from the Alleghany Mountain by Marsh Creek, which flows in a deep valley behind it, 3 miles from Howard Furnace.

Green Run exposes the Cadent lower black slates, near the base of the hills. Olive slate rocks form cliffs along the Bald Eagle Creek below Eagle Furnace; their dip is 35° N.N.W.

North of Milesburg, at the base of the first range of hills, there is a slight exposure of the Cadent and Vergent calcareous layers.

CHAPTER IV.

LEVANT, SURGENT, SCALENT, CADENT, AND VERGENT SERIES.

Little Bald Eagle Valley from Milesburg to Hollidaysburg.—South-west of Milesburg, the slope of the Bald Eagle Mountain becomes more gentle, extends half-way into the valley, and is composed of Scalent and Pre-meridian limestone and Meridian sandstone, with the lower Cadent rocks at the base. No exposures are presented by the numerous ravines descending from notches in its unusually broken summit-line. The slope is covered with a thick deposit of clay, filled with fragments of sandstone, which everywhere hide from view the position of the limestone and ore.

Fragments of the Surgent calcareous layers, full of fossils and of buff shales, were thrown out in diggings at Juliana Furnace. The ore, if present, must be high up on the mountain, which from the Martha to Hannah Furnace wears a very uniform aspect.

Three-fourths of a mile N.E. of Hannah Furnace, the irregular sparry Surgent ore limestone, interstratified with fossiliferous dark olive shales, has been uncovered beneath 4 or 5 feet of surface clay. It is based upon solid slate, dipping 45° S. 25° E.

This evinces the presence of a small synclinal flexure on the side of the mountain, or more probably an oversliding of the rocks at their outcrop. (See Diagram.)

The ore will be found probably above this line, at the distance of 1200 feet; lower down the slope sink-holes mark the outcrop of the Scalent and Pre-meridian limestones.

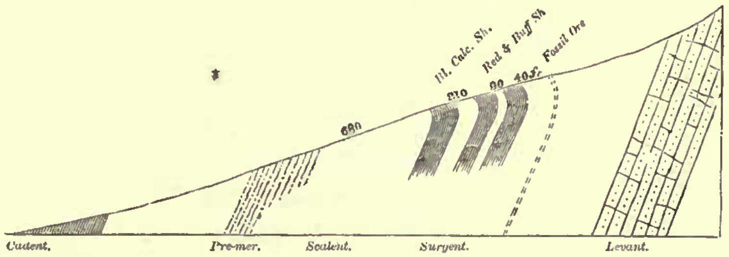

FIG. 114.—Bald Eagle Mountain N.E. of Hannah Furnace.

At Bald Eagle Furnace and at Tyrone Gap this mass of limestones has its course along the foot of the mountain.

While the mountain exhibits to the N.E. two separate crests of nearly equal height, parted by a narrow trough high up when midway between two gaps, but deepening towards these depressions, the S.E. crest, upon approaching Milesburg and Bellefonte, becomes a terrace upon the flank of the other, and, finally, towards the Little Juniata Gap both crests are broken, and the terrace becomes a mere range of separate lofty hills. Denudation has acted here with great effect. Outlines of the mountain under these three several aspects, as seen from the S.E., are given in the accompanying diagram, the summit of the Alleghany Mountain being seen in the background.

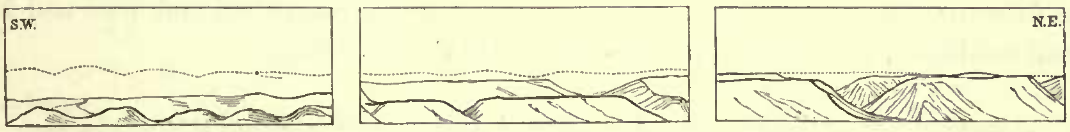

FIG. 115.—Profiles of the Crest and Terrace of Bald Eagle Mountain.

At the Tyrone or Little Juniata Gap the sandstone formations of the Levant series are exposed in strata, either vertical or overtilted into South-easterly dips. These succeed each other downwards thus,—red shale and sandstone; grey sandstone; brown sandstone; grey shale and sandstone; contorted and fractured brown sandstone; red, brown, and olive shale, dipping 89° ? S. 60° E.; brown sandstone and shale; brown sandstone and red shale; Levant grey sandstone, dark, grey, rusty, without fossils. These are followed by upper Matinal rocks, consisting of dark-brown olive slate, dark fossiliferous olive slate, grey saudy olive slate and sandstone, both fossiliferous. Five miles S.W. of the Little Juniata Gap the dip suddenly passes from the vertical or inverted to a N.W. direction, and from the less efficiency of denuding forces acting upon strata thus placed, the mountain-crest rises at once to resume its lofty regular summit-level, while the lower or grey Levant sandstone formation becomes again a high and even terrace upon its S. flank. The mountain is once more fissured at Milliken's Gap, and thence in union with Brush Mountain, its South-dipping counterpart, it runs out towards the S.W., and terminates in a long gently-declining ridge, marking the issue of the axis of the great Nittany Valley anticlinal; and here the Bald Eagle Mountain may be said to end.

Around this point, first the Pre-meridian and Meridian, and then the Cadent and Vergent strata are seen to fold, filling the Frankstown Cove, whence they issue again round the similar point of Lock Mountain and pursue their course southward, as if no such interruption had taken place.

It will be seen by a glance at the accompanying diagram (Fig. 116), that if the anticlinal flexure coming from Nittany Valley on the N.E., and that coming from Morrison's Cove on the S., had been linear extensions of each other, instead of lapping, as they do (see *a*), no such interruption would have occurred, and we should have had the Frankstown Cove rocks wholly cut off from their related ones in the Great Bald Eagle Valley, somewhat as in the ideal sketch *b* of the diagram. The beautiful form assumed by the terrace, as it fills up the end of the valley at Milliken's Gap, is shown on the Map.

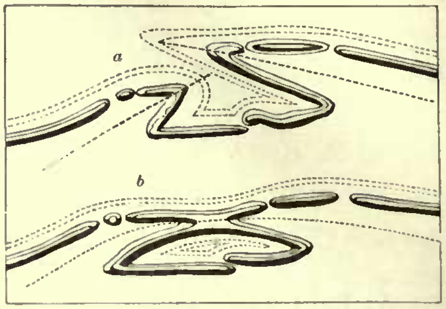

Fig. 116.—Oblique meeting of Anticlinals of Lock and Canoe Mountains.

From the point where the Bald Eagle "Brush" Mountain resumes its usual aspect and gentler N.W. dip—viz. 5 miles S.W. of the Little Juniata or Tyrone Gap—the shale and marl formations of the Surgent series again take their place along its base, which here slopes far into the Bald Eagle Valley. They are exposed along the Juniata opposite Williamsburg, dipping 40° N. 54° W. Here, as well as below Bell's Forge, the blue calcareous slates appear.

The Levant ore calcareous shales, dipping 83° N. 60° W., have been uncovered 360 yards up the mountain from Bell's Forge, presenting a layer of the ore 4 inches thick, highly calcareous and fossiliferous. Other pits too low for the ore have thrown out a poor ferruginous slate.

The following Section of Surgent shales and marls, and Pre-meridian limestone and Meridian shale and sandstone, was made along the Juniata above Bell's Forge.

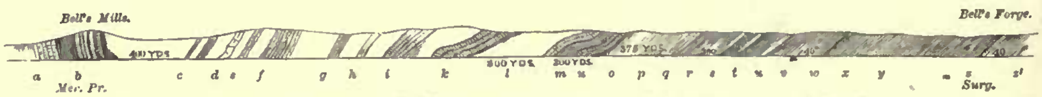

Fig. 117.—Section of Scalent Grey Marls and Limestones on the Juniata above Bell's Forge.

a Dark grey, sandy, calcareous contorted strata; Meridian sandstone, $1\frac{1}{2}$ miles from Bald Eagle Mountain, and $4\frac{1}{2}$ from Alleghany Mountain.

b Limestone; upper part argillaceous, slaty, covered by grey calcareous sandstone; lower part, blue, coarse, massive; grey silicious, coarse-grained, alternating with fine-grained; Madrepores on the weathered surfaces; a few other fossils. At Bell's Mills, Pre-meridian limestone and Scalent limestone, 400 yards; no exposure.

c Limestone, thin, slaty.
Limestone, blue, massive, with laminated calcareous ash-coloured slates.

d Sandstone, thin-bedded, surfaces weathering in grooves.

e Limestone, dark grey.

f Limestone, ash-coloured, in rough irregular layers.
Limestone, blue-grey, massive, contorted, fractured.

g Limestone, thick, rough, blue, thin interlayers.

h Limestone, argillaceous, thin ash-coloured strata.

i Limestone, thin, blue, contorted.
Limestone, dark blue, coarse, massive.

k Limestone, from 4 to 18 inches thick.
Limestone, light blue, thin, contorted.


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END OF CANOE MOUNTAIN IN SINKING VALLEY.

l Limestone, loose, grey, argillaceous, (300 yards, no exposure).
m Limestone, slaty, blue ; dark blue ; slaty, blue, thin.
n Limestone, 2 strata, each 4 feet, divided by 3 feet slate.
Shale, yellow.
o Shale, dark calcareous, dark grey.
Shale, dark grey and blackish, exposed for 40 yards, dip 38°.
p Shale, blue-green, dark blue.
Shale, calcareous, compact, blue-green.
Slate, dark blue, thin laminæ.
q Slate, with argillaceous limestone.
r Shales, ash-coloured.
s Shales, soft, dark.
t Limestone, impure argillaceous.
u Shale, blue, calcareous.
v Slates, greenish-blue, calcareous ; dark blue and olive.
Slates, blue, calcareous.
w *Fibrous celestine* in two thin layers, separated by a few inches of slate upon blue celestine ; dark-blue calcareous slates.
x Slate, dark blue, calcareous ; blue-green, calcareous.
Shales, greenish, crumbling, containing a few shells, also blue and olive.
y Shales, blue and green, and olive ; yellow compact.
z Limestone, argillaceous, covered by *red shale,* $2\frac{1}{2}$ feet.
Shale, blue and yellow.
z′ Shales, red, green.
z″ Shales, red (Surgent red shales).

The bed of fibrous celestine mentioned above (*w*), forms an interesting feature in this section. Two seams have been observed some inches apart, the lower of which is smaller and non-persistent, but the other is seen running across the whole exposure for 20 yards, and specimens may be obtained to any extent, as the walls of the bed are soft shales and slates. The mineral is crystallised perpendicularly to the planes of bedding of the enclosing slates.

CHAPTER V.

LEVANT AND SURGENT SERIES, FRANKSTOWN COVE AND DUNNING'S MOUNTAIN S.W. TO BUCKSTOWN.

The united N.E. extremities of Brush and Canoe mountains form at the head of Scotch Valley a very high bold promontory, looking out upon the great Matinal valley of Birmingham, across which the Little Juniata flows. This lofty mass consists of Levant white sandstone. The terrace of Levant grey sandstone circling round the promontory is cut up into many knobs by radiating ravines, in which denudation has laid bare the Matinal shales to a considerable depth and width. This formation is also much denuded where it forms the S.E. flank of the regular ridge of Canoe Mountain.

Opposite old Etna Furnace, 5 miles S.W. of the knob described, the mountain becomes suddenly broader and higher, and is dislocated by a sudden uptilting and overthrow of the Southern portion. Exposures along the crest of the mountain exhibit S.E. dips of only 35° and 28°.

Its bold termination at another transverse fracture looks down upon the Juniata, and forms a striking object amid the general regularity of the other mountains.

The southern fracture being obliquely transverse, the end of Canoe Mountain has been moved not simply N.W. out of line, but also towards the S.W., in an endwise or overlapping direction. The knob of S. Canoe ("Lock") Mountain, which stands on the N. side of the Juniata, and is called Canoe Hill, is the part of the fractured Levant sandstone which would fit to it, were the dislocation reduced. The rocks of Canoe Hill dip 70° or 80° W.N.W., and abut at the fault directly against the fractured ends of the Auroral limestone strata of the valley, as represented in the diagram. The turnpike, in entering Frankstown Cove over the hill which joins Canoe Hill and Canoe Mountain, exhibits argillaceous limestone and ash-coloured calcareous shale, dipping 86° W.N.W.; over this, red and yellow shales, about 100 feet thick, terminating with a dip 30° W.N.W.; then after a short interval, olive and red shales, dipping 35° W.N.W., thickness perhaps 80 feet, passing above into coarse grey, sparry, calcareous rocks, several yards thick, containing fossils.

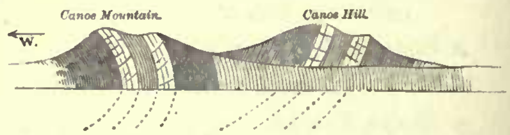


FIG. 118.—Displaced Summits of Canoe Mountain, near the Juniata.

Crossing to the terrace of Canoe Mountain, we find coarse Levant grey sandstones on the N. side of the fracture, dipping 46° E.S.E., overlying — but apparently underlying — these bedded red sandstones. Further W., rounding the end of the white sandstone part of Canoe Mountain, it shows them dipping 50° E.S.E., then olive-yellow and chocolate-coloured shales, from 200 to 250 feet thick. W. of these, 100 yards, are seen yellow and olive shales, then yellow and buff, with one or two fossiliferous calcareous ferruginous seams nearly vertical, and finally, quite on the W. slope of Canoe Mountain, the Scalent and Pre-meridian limestones.

Below the turnpike, which runs at a considerable elevation round the end of the mountain, olive calcareous ferruginous rocks have been uncovered in arched and otherwise contorted forms, but along the tow-path at the water-level we find the best section, which is as follows :—

1. Calcareous slate, dark blue, olive, yellow and greenish (45° N. 45° E.)
   (Then an interval of 180 yards.)
2. Shales, greenish-yellow (30° N. 50° W.), 50 yards not exposed.
   Limestone, massive, argillaceous, full of veins (40° N. 40° W.)
3. Limestone, greenish-yellow, soft (whole exposure 20 yards.)
4. Shales, dark, ash-coloured and blue, with more massive lighter-coloured rock (25 yards exposed.)
5. Slates, blue, dark-blue calcareous, with more solid calcareous strata, streaked with veins of spar (30 yards exposed.)
6. Slate, dark calcareous, loose and shaly.
7. Slate, dark calcareous, thin layers.
8. Limestone, in thin layers (45 yards exposed.)

9. Limestone, greenish-yellow, soft and hard (16 yards exposed.)
10. Limestone, dark argillaceous, full of veins, thick strata.
11. Limestone, bluish-yellow, argillaceous, massive, dark, sparry, 12 yards; dip 45° N. 45° W.
12. Slate, red, yellow, green (25 yards exposed.)
13. Slate, dark blue, red, and blue; veined dark.
14. Shales, broken up, red and yellow, resting unconformably upon a collapsed arch of dark argillaceous rock; exposure 20 yards.
15. Shales, red and buff; red, blue, and yellow, dip compact 38°.
16. Shales, buff (45° W.N.W.)

In M^cKee's Gap, as well as opposite Sarah Furnace, are exposures of red and yellow Surgent shales.

The W. flank of Dunning's Mountain exhibits in succession, Levant white sandstone, Surgent red shale, Scalent marls and Pre-meridian limestone.

Opposite Buckstown, the hill of Pre-meridian limestone and Meridian sandstone is separated from the mountain-base by a deep vale, furrowed out at first in the outcrop of the Scalent marls and variegated shales; then in the red and ore-calcareous shales; and, lastly, carved even in the Levant white sandstone.

This hill becomes very high, separates from Dunning's Mountain, and thence continues towards the S.

Along the S. of this, now independent ridge, runs the Surgent red-shale group, accompanied by the fossiliferous-ore group, which, although nowhere exposed, is continuously traceable by its soil and its ridged position on the slope.

Here the ore-shales are brown or chocolate-coloured, instead of olive or buff, as further N.E., but with no other observable difference. The thickness of the strata between the ore and the red shale above has much increased. The ore group sweeps round over the anticlinal axis a little to the N.E. of the termination of Black Oak Ridge, and ranges round toward the E. inside the rim of Dutch Corner.

S.W. of the gap of the Juniata River, the Levant rocks of South Canoe ("Lock") Mountain maintain uniformly for some distance a steep N.W. dip, the Levant grey sandstone forming a terrace on the S.E. slope, cut down at regular intervals by transverse gullies which carry off the drainage waters of the main mountain behind.

Canoe Mountain being joined by Lock Mountain, ends S., as it does N., in a synclinal knob, overlooking the Matinal valley of Morrison's Cove. From this synclinal knob Lock Mountain runs nearly due N. a few miles, and ends in an anticlinal point in front of Frankstown and Hollidaysburg.

FIG. 119.—View of Frankstown Knob (anticlinal), from the top of Blue Knob in the west. *a*, Frankstown; *b*, Hollidaysburg; *c*, Terrace of Canoe Mountain end; *d*, Dunning's Mountain, with its two gaps; *e*, Juniata Gap in Canoe Mountain.

Round this point and over the subsiding anticlinal which issues through it from Morrison's Cove, sweep the Surgent shales and Pre-meridian limestone and Meridian sandstone along the line of the Juniata, resuming thus their S.W. direction along the flank of Dunning's Mountain. As the E. dips in Lock Mountain are gentle, its slope descends softly into the Frankstown Cove, but the dips of the anticlinal being steep, an abruptness is imparted to the slope of Dunning's Mountain. Here, from its vertical dips, this mountain has been so denuded as to present simply two ranges of high hills for many miles to the S.W., but, from Sarah Furnace on to the Buckstown bend, its W. dips becoming less vertical, the crest of the mountain rises and grows more regular.

CHAPTER VI.

PRE-MERIDIAN, MERIDIAN, CADENT, VERGENT, AND PONENT STRATA FROM HOLLIDAYSBURG S.W. TO BUCKSTOWN, ETC.

Four miles S.W. of McKee's Gap, the relation of the Pre-meridian and Scalent limestones to the other rocks is such as is shown in the following diagram.

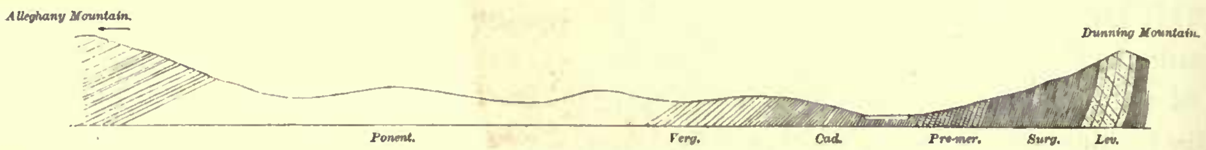


Fig. 120.—Section 4 miles S.W. of McKee's Gap.

At Sarah Furnace the rocks are well exposed. They are light-blue, magnesian, and somewhat fossiliferous limestone. Pine Ridge, separated from the base of the mountain by a valley 300 or 400 yards wide, rises near the furnace, and runs S. to within half a mile of St Clairsville. It is a broad anticlinal double range of hills, on the W. side of which rest the fragments of Meridian sandstone, and sometimes the rock itself, dipping 20° W.N.W., and on its E. side the South-east-dipping limestones.

This limestone is full of fossils. The little synclinal flexure on the S.E. side of the range

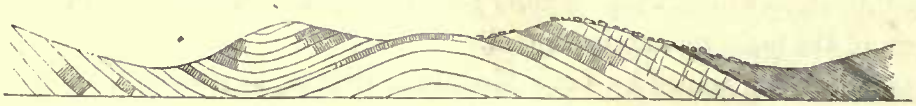


Fig. 121.—Anticlinal of Pine Ridge, with Scalent and Pre-meridian Limestone and Chert.

deepens and includes shaly limestones upon the top, which are repeated with an opposite dip upon the mountain slope. The Cadent black slates form the valley on the N. side of the ridge.

Five miles S. of the furnace there is sufficient space between Pine Ridge and the mountain to receive another little anticlinal flexure, which complicates the outcrop exposures of the limestone, as shown in the accompanying Section.

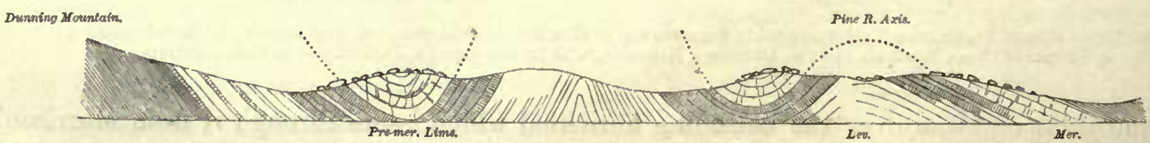
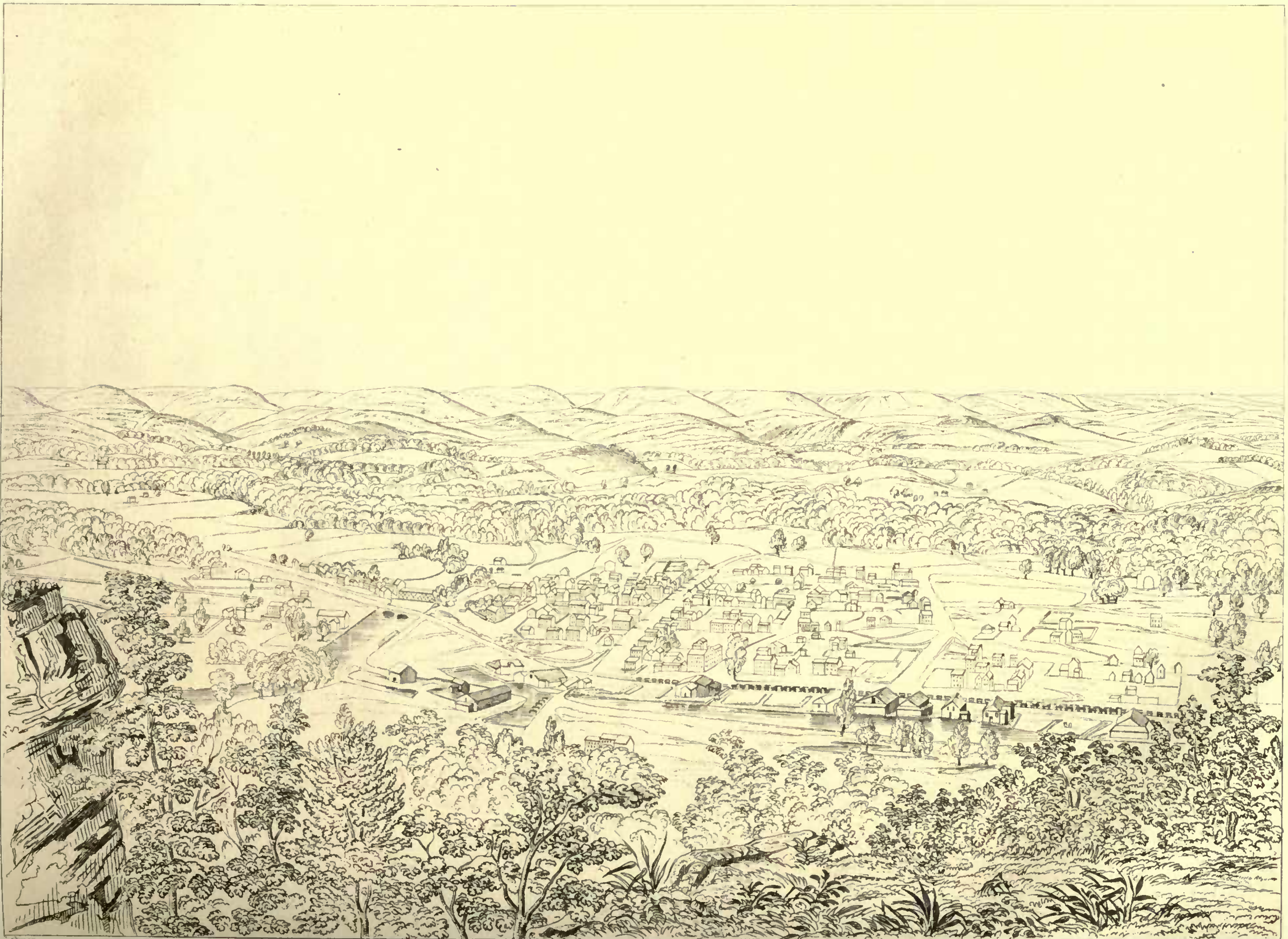


Fig. 122.—Section N.E. of Buckstown, showing Flexures and Blocks of Meridian Sandstone.



Lehman

W. & A.K. Johnston, Edinburgh.

EASTERN POINT OF THE ALLEGHANY MOUNTAIN FROM NEAR HALLIDAYSBURG.

Both these anticlinal flexures terminate about three-fourths of a mile N.E. of Buckstown, the Cadent black-slate formation sweeping round the ends of the hills that contain them. Between Pine Ridge and the mountain, the outcrop of the limestone is covered by a considerable deposit of sand and clay. Opposite the ends of the two small axes at Buckstown, the limestone begins again to form a range of low hills upon the slope of the mountain near its foot, but is evidently much crushed and contorted.

The Meridian sandstone, from McKee's Gap to Sarah Furnace, is thin and inconspicuous. S. of the furnace it forms the N. and then the W. slope of Pine Ridge, filling the soil with blocks of sandstone and masses of chert.

Cadent and Vergent Series, S.W. of Hollidaysburg.—The Frankstown branch of the Juniata River has an irregular course in the narrow valley, curved in the outcrop of the Cadent lower black-slate formation, sometimes cutting the Cadent lower olive-shale and argillaceous sandstone, which are there seen rising in an abrupt pile on its W. bank. Where the W. dip becomes gentle, as at Sarah Furnace, this hill recedes from the mountain, and the river flows through a flat. Behind this there is a second range of rounded hills, composed of the later Post-meridian shales and sandstones, and traversed by transverse valleys, the surface-soil of which is strewed with blocks of white sandstone from Blue Knob or the Alleghany Mountain. The usual dip is from 25° to 40° N. 55° W.

At Buckstown the olive shales form high hills, as they fold over the anticlinal flexures of Pine Ridge and the ridge between it and the mountain, and extend Southward parallel with Black Oak Ridge.

Ponent Series, S.W. of Hollidaysburg.—Large flat hollows, descending the flanks of the Alleghany Mountain, traverse the lofty Ponent red sandstone hills at its base, and issue through the hills of Cadent and Vergent olive shales through which the branches of the Juniata flow.

Exposures of Ponent shale and sandstone may be examined along Poplar Run, dipping 25° or 30° N., 60° W., but declining in steepness as we approach the Blue Knob. This prominent buttress of the Alleghany slope projects for about 4 miles from among the high hills of the valley. It is composed of the Ponent red and grey sandstone, and is capped with massive layers of the Vespertine. It may be said, however, to be separated from the main mountain by an elevated vale behind it, filled with red and grey sandstone. In this upland vale are the head sources of Bob's Creek and Poplar Run, which flow round the ends and also through a gap in the middle of the knob. The knob has been caused by an anticlinal flexure behind it.

From the S. end of Black Knob we look down upon a wild sea of hills without order or arrangement, separated by deep valleys, and composed of nearly horizontal Ponent red and grey sandstones. Bob's Creek flowing in an open valley, in a wide sweep to the S.E., is enclosed by similar hills, whose base and sides are covered with fragments of Vespertine sandstone and conglomerate. When traced S. for 10 miles, the Ponent hills, arranged in either two or three lines, are of less elevation.

We again find long undulating ridges descending from the Alleghany and stretching between nearly parallel water-courses towards the opposite mountain, composed of the Levant rocks. The Alleghany escarpment, itself lofty and abrupt, presents great uniformity of outline, being cleft by no deep gaps, and but little penetrated by the upper streams of the Juniata. Terraces range along its face, presenting often lofty cliffs extending for hundreds of yards, composed of the more resisting rocks, such as the massive red and grey sandstone, while the summit is covered with fragments of coarse white sandstone and conglomerate.

CHAPTER VII.

SURGENT SERIES, REGION E. OF BUCKSTOWN (DUTCH CORNER, ETC.)

We resume the description of the Surgent formations, where they fold over the axis, issuing from the end of Dunning's Mountain, inside the Black Oak Ridge, and take an E. course round the end of Dutch Corner, and then S. by the W. flank of Cove Mountain.

The Surgent calcareous group, and the Pre-meridian limestone together, form a small hill between the Black Oak Ridge and the cut of Dunning's Creek, showing steep dips N. 60° W. This is the axis that enters the N. end of Wills' Mountain and issues at its S. end, traversing Milliken's Cove. Along its whole line Surgent shales outcrop in a wide valley, the section of which offered by Dunning's Creek is as follows :—

1. Surgent ore calcareous shales, light blue; slate interlayers; full of fossils; horizontal, and much crumpled and contorted.
2. Surgent red shale.
3. Scalent and Pre-meridian limestones.

The Surgent shale and marl formation, sweeping round the curve of Dutch Corner, N.E., E., and S., presents to view a very perplexing topographical aspect, best explained by a reference to the Map; while a labyrinth of hills of every shape and size covers the surface between the foot of the mountain and the curve of the Pre-meridian ridge.

The high hills are composed of Surgent calcareous shales, with the outcrop of the fossiliferous ore, along their summits, a valley of red shale on the E., and hills of the Surgent slate formation on the W. The debris of the rusty sandstone is mixed with the surface-soil, accompanied by fragments of red ore. Further to the N. the ore runs along a valley at the foot of the mountain.

The following are the details of a Section made at the end of Buckstown Mountain :—

1. Pre-meridian limestone; 2. Scalent calcareous marls; 3. Red sandstone and slate 20° S. 40° E.; 4. Yellowish olive slates; 5. Blue slate; 6. Yellowish olive slates; 7. Yellow slate; 8. Reddish sandstone; 9. (blank); 10. Buff shale; 11. Thin calcareous, fossiliferous, ferruginous shale; 12. Yellow olive slate with limestone; 13. Massive red slate, thin silicious layers; 14. Red shale, with blue and yellow calcareous shale; 15. Red and olive shale; 16. Blue yellow slate, thin silicious layers; 17. Dark-blue calcareous thin yellow slate; 18. Blue fossiliferous limestone; 19. Surgent slate, &c.; 20. Blue, olive, and brown slate; 21. Dark olive slate (all 10°—20° S. 40° E.); 22. Fossiliferous ore; 23. Chocolate-coloured slate; 24. Brown slate; 25. Brown slate; 26. Brown and olive slate; 27. White Levant sandstone; 28. Sandstone, 3 feet (15° S. 40° E. above the ore); 29. Interval, 3 feet; 30. Slate a few inches; 31. Fossiliferous, ferruginous, calcareous slate, 18 inches; 32. Ore, 6 inches; 33. Olive calcareous slate, 4 feet; 34. Thin calcareous, fossiliferous, ferruginous slate, 1 foot; 35. Chocolate red slate. This exposure is seen 65 yards from the base of the Surgent slate hill, and forms a traceable band

in the soil, visible from a great distance by means of its vivid colour in strong contrast with the dull colours of the other soil.

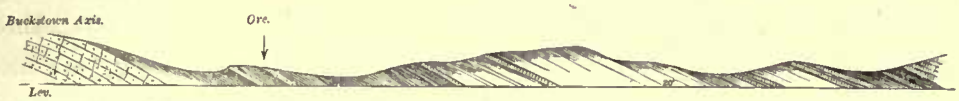


FIG. 123.—Section of Scalent and Surgent Strata opposite the end of Buckstown Mountain.

The ore is of pretty good quality, and the calcareous layers are quite ferruginous, but the latter are not persistent, being absent at another exposure of the ore some distance from this.

A wide and gentle undulation coming from the N.E. makes this cove of Dutch Corner a double one, and influences all the Surgent, Scalent, Pre-meridian, Meridian, Cadent, and Vergent formations that circle round within it.

In the more eastern of the two sub-coves, the ore outcrop ranges along the S. slope of the little range of hills next the mountain. A fragment of the stratum was picked up 9 inches square, and exceedingly rich. Appearances in a little ravine close by, seemed to justify the belief that the stratum is here 10 or 12 inches thick. It accompanies the Cove Mountain in its course S.

Here a small anticlinal is seen running (with sharp features to the N., but flattening gradually S.) in the middle formations of the Surgent series. It terminates at a point 4 miles N. of the gap of the river, where the Surgent slates and shales, and Scalent marls, are all at the foot or on the flank of the mountain, covered with a deposit of sand, clay, and loose stones. The mountain slope now extends to the base of the limestone ridge, which ends at the edge of the flat land one mile N. of the river, and contains the Pre-meridian limestone, and Meridian sandstone, next to be described. The Levant sandstones are well-exposed in the sides of the gap. They stand almost vertical, the white sandstone forming, as usual, the highest crest.

CHAPTER VIII.

CADENT AND VERGENT SERIES SOUTH AND EAST OF BUCKSTOWN IN DUTCH CORNER, AND ALONG THE LINE OF CHESTNUT RIDGE IN BLAIR COUNTY.

BLACK OAK RIDGE, rising at Buckstown, is a monoclinal elevation of the Pre-meridian and Meridian rocks, 2 miles long, at the E. base of which ranges the Surgent red shales, and at its W. base, the Cadent black slate. Its summit and W. slope are covered with fragments of buff sandstone and chert, the parent rocks of which, however, only appear at the end of the ridge. The limestone occurs along the summit, dipping 75° N. 60° W., and still steeper in the fine exposure at the S. end of the ridge. Some of the layers are full of fossils. Here Dunning's Creek sweeps across the formation, revealing 400 feet of the calcareous and argillaceous layers, which are massive above, and overlaid by the Meridian sandstone.

An irregularly continuous ridge of low hills, interrupted by cross vales, marks the line of these rocks. About $2\frac{1}{4}$ miles S. of Dunning's Creek, there is another excellent exposure of the limestone dipping 89° N. 70° W., and one more a few hundred yards further, where the strata dip 80° N. 60° W.

A series of sugar-loaf hills occupies a part of the line near the Bedford Turnpike, opposite the end of Wills' Mountain, between which and these ranges a much higher belt of hills, composed of the Pre-meridian and Scalent limestones, much crushed and contorted, although no distinct anticlinal structure, implied by their presence, could be detected. Between these last-mentioned hills and the mountain are the usual little knolls composed of the hard rocks of the Scalent groups.

The strata exposed at the Bedford Turnpike near its junction with the Somerset Road in the end of the ridge, are thin, rough, light-blue magnesian limestones, alternating with irregular and more massive layers, containing seams of chert and fossils, and dipping 75° N. 50° W.

Where the Juniata passes through the ridge it is nearer the mountain, and exhibits vertical or even overturned dips, the strata often crushed and contorted, as in the following section taken near the bridge.

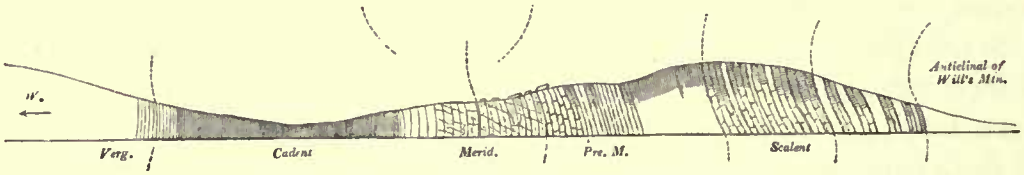


FIG. 124.—Section of the End of Lime Ridge, near Bedford.

a Olive slates of Cadent series.
b Olive black slate of Cadent series.
c Meridian sandstone, massive (71° N. 60° W.), rough and fossiliferous.
d Meridian silicious slates full of fossils.
e No exposure for 30 yards; fragmentary buff sandstone.
f Silicious (cherty) strata.
g Limestone, dark-blue and silicious, weathering dark-grey.
h Limestone, massive, dark-blue.
i Slates, dark-blue, silicious, calcareous, and sparry; 75° N. 60° W.
j Limestone, pure.
k Limestone, massive, cherty, and full of fossils.
l Limestone.

On the E. side of the Buckstown (Wills' Mountain) anticlinal axis in the synclinal basin of Dutch Corner, the broken ridge of Pre-meridian and Meridian strata forms a long triangular or angular loop, presenting two projecting knobs Northward to each small cove at the head of Dutch Corner, and a third one, a long point, Southward to the town of Bedford.

The summit of the ridge is composed of limestone rocks, the inner slopes of Meridian sandstone, and in the midst of it we see another smaller triangular tract of Cadent and Vergent rocks.

The W. side of the triangle contains rocks dipping 30° S. 65° E. Interstratified layers of thinly-bedded and massive limestone, with many fossils, are exposed in a quarry $1\frac{1}{2}$ miles N. of Dunning's Creek Gap; and half a mile further N. there is another quarry, also in massive blue fossiliferous limestone, with partings of slate.

Round the high knob at the N.W. angle, circle hills of the Scalent calcareous marls, which upon the N. side have vertical dips, implying much compression in the synclinal flexure. The N. side is cut through by a very wide gap, by which a stream enters the synclinal basin. Here the rocks dip 20° to 30° W., 15° S., and the Meridian sandstone also shows itself.

Just S. of the N.E. angle there is a gap, in which the rocks dip 25° N. 60° W.; and one mile

S. of this occurs another gap, S. of which the ridge is little more than a broken range of hills, rising and growing steeper until it unites with the W. ridge, and terminates in a bold knob within sight of Bedford. Excessive denuding action directed towards the river gap, must have swept the hills of the synclinal trough away, and smoothed the surface to a plain.

The end of the ridge presents one of those perplexing conditions of the dipping of the strata which occur along the axes of flexures, which have interfered with each other, or been dislocated.

The Meridian sandstone, very fossiliferous, occurs everywhere on the ridge just described in fragments, but it is seldom in place, and is a thin formation.

CHAPTER IX.

CADENT, VERGENT, AND PONENT STRATA SOUTH-WEST OF BUCKSTOWN.

A SECTION along Bob's Creek, at Buckstown, wears the aspect here represented. In it we observe, for the first time, the Chestnut Ridge axis, which lifts the Pre-meridian limestone and Meridian sandstone for 10 miles to the S. along the centre of the Great Valley, composed of Cadent, Vergent, and Ponent rocks.

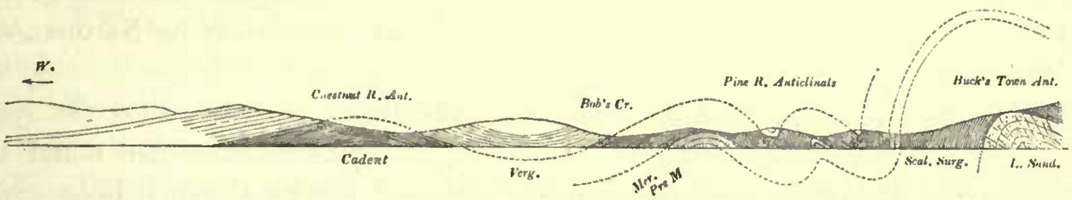


FIG. 125.—Section on Bob's Creek at Buckstown.

Upon Bob's Creek the strata elevated by the N. end of the Chestnut Ridge axis are the Cadent lower black slates. These are nearly horizontal, and contain dark-blue, grey, lenticular, calcareous nodules, full of veins, and they exhibit a reticulated surface like a tortoise-shell. They are imbedded in soft dark-brown shale.

The horizontal black slates form an extensive flat extending to Dunning's Creek, where, at the " Alum Bank," they are exposed for a length of 600 or 700 yards, with a vertical thickness of 50 feet. Here the lenticular nodules of carbonate of lime are again seen, some of them measuring 4 feet in diameter. Within, perhaps, one-fourth of a mile from the " Alum Bank," the rocks begin to rise W. over the axis of Chestnut Ridge.

Chestnut Ridge ranges from Dunning's Creek (2 miles above the mouth of Bob's Creek), S.W. At first it is a low hill raised on a gentle arch of Meridian sandstone, and covered with fragments of the same rock ; further forward it has a double summit, enclosing a little valley, formed of the Meridian slates, in all the hollows of which, if the superficial clay and sand were removed, might be seen the Pre-meridian limestone. It terminates as a single ridge again, about $1\frac{1}{4}$ miles S.W. of Shellsburg. The soil upon its sides, where extensive deposits of sand and clay with imbedded fragments of chert have been formed, is good, though inferior to that upon the summit where the debris covers the surface. Very fine specimens of crystalline hæmatitic iron-ore have been obtained within the ridge; but extensive experimental diggings have developed nothing. The usual dip of the rocks is from 5° to 15° N., 60° W., and S. 60° E.

Sometimes the Cadent lower black slates stand out in suites of smooth, low, rounded knobs upon the rough flanks of the ridge. Looked down upon from the Alleghany Mountain, 5 miles distant, Chestnut Ridge has not sufficient height to stand out from the apparent plain. Between them rolls the broken country of Cadent, Vergent, and Ponent rocks. The Shawnee fork of the Raystown Branch of the Juniata cleaves its ridge near its S. end, exposing highly fossiliferous Pre-meridian slates, some few layers of Pre-meridian limestone, and here and there a little of the Meridian sandstone, all nearly horizontal, the latter rock containing many fossils, and at times so coarse as to be a true conglomerate.

This axis runs on Southward beyond the end of the ridge into Somerset County. W. of it, among the Cadent and Vergent hills, are occasional exposures of the Meridian fossiliferous sandstone, dipping 25° or 35° N., 50° W. Along the S. prolongation of the axis the hills are very high, and covered with fragments of grey sandstone, and sometimes of the older red Ponent rocks.

Dry Ridge, at the N. base of which the Raystown Juniata flows, stretches as a range of hills, with a steep escarpment towards the N.W., from the first gap in the Buffalo (Wills') Mountain, across the broad valley, and blends with the high hills at the base of the Alleghany. Its S. E. slope is gentler, and in the form of long ridges, at right angles to the "Dry Ridge," and projected towards Wills' Mountain. These hills, composed of the newer sandstones of the Meridian series, fill the trough of the Savage Mountain synclinal, and circle round its Northern end, as shown in the Map.

This is but the S. continuation of what, for convenience, may be called the synclinal basin of Buckstown, beginning at the N., where the Pre-meridian rocks fold round the S. ends of the two little Pine Ridge axes, and running Southward with the Chestnut Ridge anticlinal on the W., and the great anticlinal of Buckstown or Dunning's, and Wills' mountains, on the opposite side.

At Buckstown are developed the Cadent lower black slates, which here, as in so many other places, have been fruitlessly opened in search of coal. Numerous wrinklings of the rock along Bob's Creek, W. of the village, mark the continued action of the force that formed the two little axes of Pine Ridge. Between Bob's and Dunning's creeks, the hills, which are steep toward Chestnut Ridge, and gently sloping Eastward, consist of Cadent Lower shales, Cadent newer black slate, and Vergent flags. These are exposed along Bob's Creek; while often higher up, on the flank of Black Oak Ridge, we find the Cadent older black slate.

The effect of the little Pine Ridge axis may be traced even in the valley of Dunning's Creek in a gentle anticlinal flexure, which occurs just E. of Chestnut Ridge, but is not observable in exposures further along its range in a S. direction.

Below the mouth of Bob's Creek, Dunning's Creek frequently exposes olive-brown and black Cadent slates and shales, alternately dipping gently E. and W., as if a number of small flexures crossed the valley. Still descending the creek and approaching the Pre-meridian exposures, the dips increase until they become nearly vertical.

S. of Dunning's Creek, the denudation of this synclinal trough has been chiefly in the direction of the strata. The hills are highest along the central line of the trough, where they are all capped by the comparatively hard mass of the Vergent flags. Three-fourths of the thickness of the whole Cadent and Vergent series is found in these middle hills. This synclinal maintains its regularity throughout, presenting very steep or vertical dips along its E. margin, as will be seen in the following Section :—

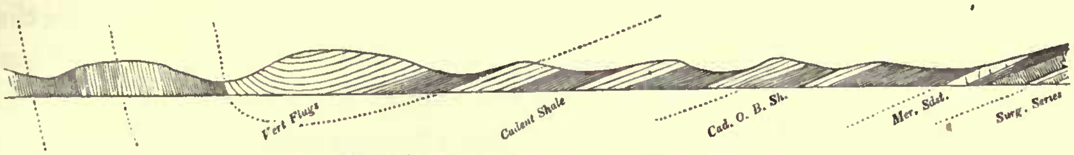


Fig. 126.—Section on Bedford and Greensburg Turnpike.

Ponent Series, West and South-west of Chestnut Ridge Axis.—The first gap in the hitherto unbroken escarpment of the Alleghany Mountain is made by a short brook, three-fourths of a mile S.W. of which is another gap without a stream, which has been selected as the most practicable for the ascent of the Bedford and Greensburg Turnpike. Here the mountain is observed to have two crests : one formed of the edge of the Vespertine conglomerate ; the other, behind and higher than this, by the seral conglomerate. Between them lies a terrace of the Umbral shales, and in the upland behind the second we meet the Coal-measures. A few miles further S. the mountain has but one crest.

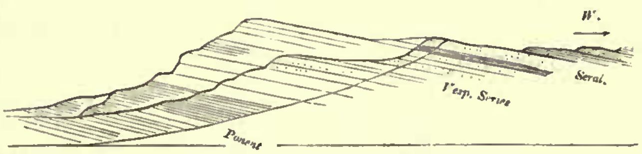


Fig. 127.—Form of the Escarpment of the Alleghany Mountain.

In ascending this dry gorge along the Turnpike, we meet in succession red shales with thin sandstones ; buff and brown micaceous sandstones, 15° N. 60° W. ; and grey micaceous massive sandstone, all belonging to the Ponent series. These, half-way up the mountain, are followed by cliffs of dark-grey fissured coarse sandstone, which are Vespertine.

S.W. of the Turnpike the mountain-crest is lower and more broken, and the flank more deeply trenched. The next gap, 10 miles distant, is that through which Breastwork Run descends, and $2\frac{1}{2}$ miles further on, the Somerset Road descends to Bedford by another notch.

CHAPTER X.

COUNTRY SOUTH OF THE RAYSTOWN BRANCH OF JUNIATA IN THE FOURTH BELT OF THE SIXTH DISTRICT.

BEDFORD SYNCLINAL BASIN (CUMBERLAND VALLEY) FROM BEDFORD TO THE MARYLAND STATE LINE—SURGENT, PRE-MERIDIAN, MERIDIAN, CADENT, AND VERGENT SERIES.

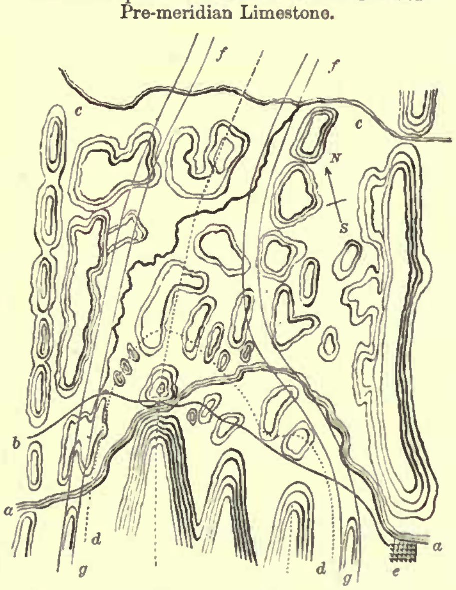
SURGENT SERIES.

The flank of Cove Mountain, S. of the Raystown Juniata Gap, consists as usual of Surgent slates and shales, the slates rising high towards the crest and dipping nearly vertically. But from Bedford to the gap which leads into Friend's Cove, not an exposure of rock was observed.

The Scalent calcareous layers, dipping 80° S. 70° E., in an inverted position, occur in the gap 12 miles S. of Bedford. The mountain is extremely regular, and its lateral ravines shallow, conditions due perhaps to its being protected from denuding violence by the wall of Wills' Mountain.

A little N.E. of Hendrickson's Gap the overturn is not so decided, but otherwise, the whole geological aspect of the mountain remains the same, the surface being covered with fragments of Levant white sandstone, and the clayey soil mingled with fragmentary shale as far as the State line. Nowhere was the fossiliferous ore discovered, although every ravine was searched for evidences of its presence. On the W. side of the Cumberland Valley, on the contrary, there is no difficulty in finding it everywhere in its line of outcrop.

FIG. 128.—Map of Vicinity of Bedford, showing the Outcrop of the Fossiliferous Iron-Ore and Pre-meridian Limestone.



a a is the Juniata River; *b* the Turnpike; *c c* Dunning's Creek; *d d* the Ore Outcrop; *e* Bedford; *f f* tho Ranges of Red Shale and Sandstone.

The accompanying diagram exhibits the outcrop of the ore, marked by a ferruginous-coloured strip in the soil of the fields as it circles (*d d*) round the three anticlinal knobs composing the N. end of Wills' Mountain. The ore-shales make their appearance on the anticlinal at Dunning's Creek, but the denudation around the ends of the mountain has cut into the Surgent shale-formation below the ore-shales.

As the South-eastern dip inclines less than the North-western, the ore outcrop is much nearer the mountain on the Eastern than on the Western side.

At the side of the ridge described in a preceding Chapter as composed of Pre-meridian limestone and Meridian sandstone, there is a series of hills running from Dunning's Creek to the river, which expose the blue, green, and yellow calcareous slates, and argillaceous Scalent limestone layers immediately beneath the former, while ravines between the hills exhibit the East-dipping red-shale formation which constitutes their foundations.

These rocks are again made visible by the cuttings on the Hollidaysburg Turnpike. The fact that a separate hill or ridge is appropriated by each of the four hard belts of rocks, the main Pre-meridian limestone, the Meridian sandstone, the argillaceous limestones of the Scalent group, the sandstone bands in the Surgent red-shale formation, and the sandstone of the ore group, will in many cases facilitate the exploration of this and like regions for the discovery of the fossiliferous iron-ore.

FIG. 129.—Section on Hollidaysburg Turnpike.

On the gently-rounded hills S. of the river, specimens of ore are frequent in the rusty streak of soil marking the course of the outcrop across the fields. They are of a deep red colour, rich in iron, and, in some cases, crowded with the characteristic fossils. The bed of ore in this locality, though tested by openings, did not promise much thickness.

One mile S. of the end of the mountain, the ridge of Scalent calcareous marls rises from the denuded flat of the river, and for some distance maintains its usual position along the side of the mountain, presenting occasional and sometimes very wide transverse breaks. The ore group forms a low ridge upon the broad and gentle slope of the mountain, as in Sections (figs. 130, 131). The red shale, becoming very thin towards the S., is seen to be associated with a greenish

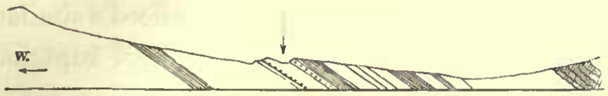


FIG. 130.—Section on Dedding's Creek, and 1 mile S.

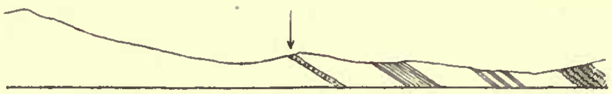


FIG. 131.—Section on Dedding's Creek, and 1 mile S.

slaty sandstone, as appears upon a small stream which descends the mountain 2 or 3 miles from its N. end. Here occur in succession downwards slaty limestones, Scalent marls, a band of red rock, perhaps 20 feet thick; some distance beneath this, limestone strata in several exposures, dipping 20° S.E.; and, lastly, some ferruginous contorted layers, but without any distinct bed of the ore. The Section represented in fig. 131 was made 4½ miles S. of the end of the mountain. Still further S. the dips are not more than 15° or 20° S. E. On comparing numerous sections made at intervals along the course of the mountain, it will be seen that the denudation has been variable in direction and intensity at different places. The ore-bed is frequently marked by a ferruginous-coloured streak in the fields, and by the coarse sandstone fragments upon the surface. Sometimes extensive flats occur between the steep mountain-slope and the denuded base of the limestone ridge.

The chief change to be remarked, as we trace the outcrop of the Surgent series Southward, is that the red-shale formation becomes more silicious, assuming more the character of a red sandstone, and, from its increased thickness, forms near the Maryland line a distinct ridge of considerable height. Here grey sandstone begins to be intercalated in the red, in massive but not numerous beds. In some layers of the formation beautiful fucoides, like twigs of bushes, are of common occurrence. The dip varies from 30° to 40° S., 60° E.

Another line of hills at the base of the mountain, and of tolerable regularity, gives surface specimens of the fossiliferous ore and yellow sandstone.

A section made at the Maryland line presents the Pre-meridian, Scalent, Surgent, and Levant strata under the following characters:—

1. Pre-meridian limestone.
2. Scalent calcareous marls.
3. Surgent red shale and yellow and red massive sandstone.
4. Blue slate and limestone: the latter full of fossils, and slightly ferruginous; blue slate; light-blue thin-bedded limestone; rough grey sandstone; slate; thin rough fucoidal sandstone; slates, lead-coloured.
5. Fossiliferous ore; massive brown and yellow slates; yellow slate; brown and chocolate-coloured slate; light buff slate.
6. Levant white sandstone of Wills' Mountain.

The calcareous layers, usually associated with the red shale and ore formations, form together a thin mass, removed to a greater distance (perhaps several hundred feet) from the ore group than elsewhere. They are thinly-bedded, light-blue, and much intermixed with slates.

The ore itself could not have been discovered in place without pretty extensive digging, but from surface indications it must be a thick and valuable bed. It is not known whether the yellow sandstone occurs here above or below the ore.

The Scalent limestone is an extensive formation, its yellow and blue calcareous layers being of some bulk. In the lower members occur layers of magnesian limestone, which afford a similar variety of cement stone to that wrought at Cumberland, and which is said to be of superior quality.

CADENT AND VERGENT SERIES.

The rocks upon which the town of Bedford is built are very much contorted. The synclinal flexure of Dutch Corner passes the town Southward, nearly as in the accompanying Section, *a* being the marble quarry of massive grey fossiliferous limestone; *b*, thin whitish limestone.

FIG. 132.—Section at Bedford.

The strata of the Western limestone hill range towards the S. greatly crumpled and fractured, but maintaining a general Eastern dip.

The topography of the valley S. of Bedford is complicated by the presence of two anticlinal flexures, one passing by the town, the other through the hill at the Springs. The long slope at the S. end of the W. axis is covered with fragments of Meridian sandstone, and the Cadent black slates which fill Shaver's Valley sweep round the point. This axis is perhaps 1½ miles long. It elevates the Meridian sandstone. The high hill between the two is covered with fragments of the same sandstone, and of the buff sandstone and chert.

East of the E. axis there is a yet higher knob, at the base of which the hotel at the Bedford Springs is built, and a gorge through this exhibits the following section, including the N. end of a third axis about 2½ miles long.

Cadent lower black slate; Meridian thinly-bedded sandstone; Sandstone, light-yellow, cherty, with slate layers full of fossils, perhaps 50 feet thick (40° W.) (Interval.) Slates, silicious twig-like fossil impressions. (Interval.) Limestone, magnesian, silicious, light-blue; Limestone, pure blue; Limestone, light-blue, magnesian, sparry; Limestone, massive, light-blue, magnesian. (Bedford Spring issues here.) Limestone, dark-blue, edges grooved by weathering; Limestone, dark-blue, massive; Limestone (two strata, each 5 feet thick); Limestone, compact, light-blue, magnesian (perhaps 70 feet thickness of rocks between this and the layer at the Spring); Limestone, rough and massive, disposed to a nodular structure, very fetid when struck, full of fossils; Limestone, dark-blue, pure-veined (30° S. 85° W.); Limestone, dark-blue, 5 feet, weathering whitish; Limestone, light-blue, magnesian, crushed, 6 feet; Limestone, grey crystalline, full of encrini, 5 feet; Limestone, light-blue, full of veins and fossils; Limestone, thin, grey, encrinitic; Limestone, thick, blue, cherty, fossiliferous, 6 feet; Limestone, light-blue, pure, 10 feet; Limestone, blue, compact, veined, few fossils, 10 feet; Limestone, whitish, slaty, 4 feet; Limestone, grey, full of seams of chert, 5 feet; Limestone, grey, crystalline, full of fossils, 5 feet; Limestone, magnesian, massive, at the mill below the Spring. Here the axis occurs, and the above-described rocks, rolling over, descend again Eastward in obedience to a narrow synclinal flexure, which is succeeded by the overturned steep E. dips of the deeply-fissured limestone ridge. The folded synclinal flexure forms a sharp trench along the base of Cove Mountain.

By reference to the following Section (fig. 133), its structure is made apparent at a glance.

The anticlinal hill above the Spring is covered with fragments of chert and sandstone; the buff-coloured sandstone fragments contain many casts of fossils. In the gap through this hill 1½ miles S. of the Springs, there are good natural exhibitions of the Meridian sandstone, which is a coarse, grey, massive, and blue calcareous fossiliferous rock. In the next gap towards

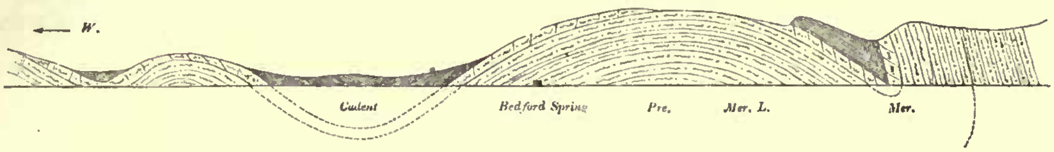


FIG. 133.—Section 1 mile S.W. of Bedford.

the S. the same beds are seen in horizontal position, and a little further S. the Cadent black slates sweep round the end of the ridge, the axis sinking and expiring.

These Cadent black slates not only occupy the synclinal basin of Shaver's Valley, but also a long and narrow vale caused by the collapsed synclinal flexure. The little valley runs along between the limestone hills at the foot of Cove Mountain, and the high hills containing the third or most Eastern little axis last described. (See the diagram.) The limestone hill along the foot of Cove Mountain here becomes a regular ridge about 2 miles S. of Bedford, which continues for 12 miles, cut however by transverse gaps, and generally separated from the mountain by a deep hollow. From Hendrickson's Mill to the Maryland line (8 miles) no hills of any height occur along this outcrop ; it is marked simply by a range of sink-holes following the almost imperceptible slope of Evit's (Cove) Mountain. The strata are vertical or overturned, the flat covered with diluvial clay and sand, imbedding sandstone fragments, and the soil is too rough and barren for tillage.

On the flank of Wills' Mountain the Cadent and Vergent rocks form a bold and regular ridge 4½ miles long, the side presented to the valley being covered with loose chert and sandstone, and exposing sometimes the rock in place, dipping 35° or 40° S., 60° E. The black slate rests at the base, or mounts the hill-side. The W. or outcrop margin shows marks of violent but partially resisted denudation. The ridge continues beyond Limestone Gap, and beyond Steele's Gap, with a similar aspect, except that its crest grows higher and more undulating.

At the gap 5 miles S. of Steele's Gap, denudation has effected what seems to a casual observer a structural change and deflection of the ridge, but the dip will be found unaltered. It is 30° S. 60° E.

A small anticlinal enters from the middle of the valley, and widens the ridge about 9 miles S. of Bedford. Still further S., and along Evit's Creek, these East-dipping Cadent and Vergent rocks become vertical, and even overturned ; the slopes of the ridge become very steep, and exposures of the limestone and sandstone begin.

South-west of the narrow flat of Evit's Creek, a broad, high, double range of hills, irregular in their topographical features, presents a striking contrast to the single line of lower, more rounded summits of which it is the Southward prolongation. The change is due to another of those numerous lesser anticlinal flexures which fill the Cumberland Valley, entering the ridge, or rather lifting a parallel ridge of Pre-meridian limestone and Meridian sandstone by its side. The double range continues to the Maryland State line. So high are the knobs along its undulating crest, that to a spectator in the valley they appear of equal altitude with either of the bounding mountains. Their strata dip from 25° to 45° S. 60° E. Their summits are not destitute of exposures of the strata, though strewn over with fragments of chert and sandstone. The order of the beds descending is as follows :—

1. Light argillaceous yellow-coloured sandstone tinged in streaks with oxide of iron.
2. Silicious limestone, with layers of interposed chert, and fossiliferous dark slaty sandstone, the latter not always present.
3. Dark-blue pure limestone, with shells and fetid grey crystalline massive limestone, with corals, encrini, &c.
4. Massive magnesian and dark-blue pure limestone.
5. Thin-bedded light-coloured limestones, with partings of slate.

The anticlinal flexure described above passes the State line with all its features strongly marked. At one place N. of the line a small saddle or anticlinal roll is seen in the middle of the synclinal valley E. of its axis, and runs a length of 1½ miles through the body of an irregular ridge. The following section will express this little axis where it exists, and excluding it, the section describes the state of things at the State line.

Fig. 134.—Section of the Cumberland Valley at the Maryland Line.

The admirably regular forms into which the more symmetrical flexures cast the outcrops of the harder rocks of the Palæozoic series are well illustrated in the Cadent black slates, Cadent olive shales, Meridian sandstone, and Pre-meridian limestone in Dutch Corner.

An included belt of the same Cadent and Vergent rocks lies along the synclinal valley of Cumberland from a point one mile S. of Bedford to beyond the Maryland line, but is subjected to all the local interruptions and deflections consequent on the presence of its small anticlinal flexures.

Thus 9 miles S. of Bedford the bottom of the synclinal so rises as to shut out the Cadent and Vergent series, while the Pre-meridian rocks roll from side to side of the valley. The same occurs again further S. at Hendrickson's Mill.

The black slates of Shaver's Valley have been penetrated—fruitlessly, of course—in search of coal, 1½ miles S. of Mr Reynolds'.

CHAPTER XI.

COUNTRY WEST OF BUFFALO MOUNTAIN.

Surgent Series.—Southward from the place where the Juniata has its course in the Surgent slates and shales, the strata are first almost, and afterwards quite vertical, and passing the first gap they are actually overturned with a steep S.E. dip. This they maintain with slight variation to the S. end of Milliken's Cove, where the Buffalo and Wills' mountains coalesce. From the summit of the mountain the slope is steep, and the surface is covered with fragments of the Levant white sandstone. To this succeeds a long gradual descent, showing Surgent slates, shales, and marls, but displaying no indications, even at the gaps, of the presence of the fossiliferous iron-ore. At the foot, we reach the little ridge of Scalent and Pre-meridian limestone and Meridian sandstone.

South-west of the point where the two mountains become one, the overturn of the strata disappears, and they dip again as usual almost 40° W.N.W.; but the prevailing projection or relief of the Surgent series has yielded here to the violent erosive action which scooped out the valley of Wills' Creek. South of the forks of Wills' Creek, the valley grows narrow, and the Surgent marls and shales appear upon the E. side of the ridge of Scalent limestone. The creek continues its winding course in a low flat plain, which is from 350 to 500 yards in width, sometimes washing bare the mountain sandstone on one side, sometimes the Scalent marls on the other.

The Pre-meridian Limestone.—South of the river flat, where all the outcropping formations are denuded to a level, and one mile from the bridge above the gorge at the end of Wills' Mountain, the limestone ridge rises and continues for half a mile to Metzger's old tavern. The strata are vertical and full of fossils.

At the Sulphur Spring Gap, the second notch in Buffalo or Wills' Mountain, the limestone ridge is lofty, its terminal knob being half as high as the neighbouring mountain. Its strata continue vertical, or slightly overturned.

Approaching the third notch on Swigert's Gap, the ridge which had previously assumed the form of a terrace on the mountain slope, declines in height, numerous lower hills of Cadent lower black slate, and Cadent shales, attending it on the N.

From Millar's to the last notch, or Buffalo Gap, leading into Milliken's Cove, the limestone scarcely makes its presence known in any way, but 1½ miles N.W. of Millar's house, the Meridian sandstone, a grey, calcareous, coarse-grained rock, is well exposed, weathering with a brownish-yellow surface, and showing few fossils.

South-west of Buffalo Gap, the limestone again forms a ridge, increasing in height towards the fork of Wills' Creek, where it is broken through by both branches of the stream. At its N. end this portion of the ridge exhibits vertical strata of the Meridian sandstone, the large blocks of which cover its W. slope throughout its entire length. In the gap of Big Wills' Creek are five exposures of the Meridian sandstone, which is here a grey or dull-olive coarse-grained rock, full of its characteristic fossils, and in a nearly vertical position. It continues to increase in mass Southward. Below are seen the sandstone layers of chert; then massive Pre-meridian limestone, blue and pure, and in some layers fetid; and underneath these, ashy blue, soft beds; the whole mass composed apparently of shells and other fossils. These softer layers have been mistaken, by persons not familiar with rocks, for gypsum or plaster-of-Paris.

Beneath these lie thin-bedded blue limestones, veined, and full of fossils, becoming still thinner descending. These are in part the Scalent limestone.

The whole exposure is about 170 yards long, and exhibits a thickness of rock of perhaps 350 feet. Continuing its course (broken by two gaps) Southward from Wills' Creek for 3 miles, this steep and narrow ridge flattens out at its summit, and affords a width of half a mile of flat and admirable farming land. "Sink-holes" are met with occasionally in the fields. The Western slope is covered, as elsewhere, with fragments of sandstone and chert. This widening of the ridge is due to a gentle undulation. The steep vertical outcrop of the flexed strata becomes, further S., 5 miles beyond Wills' Creek Gap, an exceedingly high, indeed mountainous ridge, too rugged for cultivation at any point, but it is covered with fine timber. It is traversed by a wide deep gorge—that of Thompson's Run—along which occur frequent exposures of the grey calcareous sandstone and limestone, in many contortions, in the general flexure. An imperfect section here reads as follows :—

Cadent Black Slate.—Black, or dark slate, in thin layers ; blue, almost black, coarse shale, perhaps 250 feet thick ; blue slate, dipping 70° N. 60° W. ; Meridian white sandstone, a thick stratum ; Meridian shale, a light argillaceous sandstone, orange and variegated, with bright blood-coloured stains, weathering into a ferruginous clay, 250 feet—interval 50 feet ; Pre-meridian limestone—limestone in massive strata ; Surgent shales, &c., in the valley of Wills' Creek. The whole length of the exposure, including all the interval, without exposed strata, is 120 yards.

Sometimes the whole rock seems merely a slightly indurated clay. Where silex is the preponderating element, it furnishes the surface fragments, so often spoken of as covering the Pre-meridian limestone ridges. They seem sometimes to be merely an agglutination of quartz particles, and sometimes to resemble the rotten-stone of commerce, but they are full of fossils. The disintegrated sand from the rock forms admirable roads, such as that leading to Shellsburg, and that on Black Oak Ridge. In some localities layers of chert occur in this yellow sandstone, the chert also being full of fossils.

On branches of Gladding's Run are other exposures of the Meridian series, showing a hard, dark-blue, coarse, slightly calcareous sandstone, a black silicious slate, and a grey sandstone, dipping 28° N. 60° W. ; also a black silicious slate, with blue and ash-coloured strata, succeeded by Cadent black slate.

The limestone appears at intervals along the ravine of Thompson's Run ; the upper strata are very massive ; the lower are thin-bedded, and belong to the Scalent series. Gladding's Run makes a curved sweep through the flat axis, and exhibits a section, represented in the diagram here annexed.

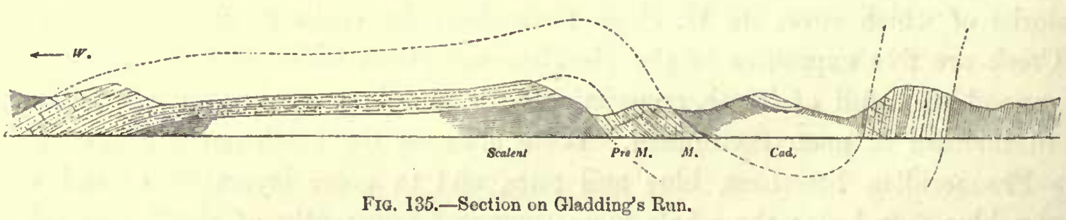


FIG. 135.—Section on Gladding's Run.

A wall of massive horizontal limestone, 60 feet high, beetles over the stream, for a length of 700 yards. Some of the beds are silicious, and full of fossils ; some are pure limestone, separated from each other by layers of chert. The whole vertical thickness of the mass may not exceed 90 feet ; the dip being less than 10°. Deep fissures and chasms intersect it.

The Cadent black slates are finely exposed at Samuel Devore's, near the church. They lie in the synclinal trough, which is here about 500 yards wide ; but deepening, it expands Southward into Maryland. The anticlinal flexure dies out along a range of high hills, with steep slopes to the valley of Gladding's Run on one side, and to Wills' Creek on the other. At the first gap, S.W. of Gladding's Run, the grey Meridian sandstone dips 38° N. 60° W., and a ledge of dark-blue calcareous sandstone, and of coarse grey sandstone, dips at the same angle on the other side of the stream. These notches or gaps are about 500 yards in length.

At Porter's Mills, in the next gap, dark silicious slates and thin layers of chert occur, dipping 35° S. 60° E.; and 9 yards from these is dark-blue limestone, with slates between them, nearly horizontal; and 60 yards further, dark-blue rough and massive limestone, weathering white, full of fossils, and exposed for 100 yards, dipping from 20° to 40° N. 60° W.; and this completes the axis. At the upper end of the gap appear the Cadent black slates.

At the next gap we find an exposure 400 yards in length, presenting, first, dark-blue and grey Meridian sandstone, weathering white, and dipping 35° S. 60° E. This stratum flattens and falls over Westward, in a regular and beautiful arch, and disappears with a dip of 38° N. 60° W. Next in order are dark-blue silicious strata, showing, on the weathered surfaces, nodules of chert. Lastly, dark-grey, coarse-grained, fossiliferous sandstones complete the exposure.

This, like all the rest of these gaps, is but a prolongation transversely through the Pre-meridian and Meridian range of a valley descending Westward, through Cadent and Vergent hills. It cuts through the anticlinal flexure only 500 feet from its apparent termination. Around the end of the flexure sweeps the escarped outcrop of the Vergent shales and flags, which enter Maryland, which is within half a mile. The perpendicularly-dipping Pre-meridian limestone, and Meridian sandstone, continue Southward from Thompson's Run in a separate, broken ridge, or line of low hills. At one place along the creek, the Scalent marl group exposes two small flexures, not traceable Northward or Southward.

Cadent and Vergent Series.—Dry Ridge has already been described as composed of the Cadent shales lying in the broad synclinal hollow between the great Wills' Mountain (or Milliken's Cove) anticlinal and the lesser anticlinal flexure of Chestnut Ridge. About 4 miles S. of the river, along the E. margin of this synclinal trough, the Cadent olive-slate hills approach Buffalo or Wills' Mountain, and blend their slopes with those of the Meridian range already noticed. The synclinal trough contains, however, so great a thickness of the Cadent and Vergent series along its axis or central line, as to form there the highest ground; and to this elevation has been applied the name of Dry Ridge.

Five and a half miles S.W. of the N. end of Dry Ridge, the lower members of the Ponent series are found upon its summit. The synclinal trough continuing to deepen and widen S. towards Savage Mountain, more and more of the Ponent rocks enter it, and the main summit of Dry Ridge, with gentler E. dips, is thrown off W.; while a lesser summit, with vertical or steep W. dips, is also thrown off to the S.; and these two Cadent and Vergent encircling summits constitute, as it were, a line of outer ramparts to Savage Mountain. These features may be seen on the Map and in the general Section.

Tracing the left-hand or E. outcrop of the Cadent and Vergent rocks, we find at Hugh's Camp Run a section of the Vergent and lower Ponent rocks which form the highest summit of the range of hills between Wills' and Savage mountains.

This exposure displays a stratum of massive, compact, white quartzose conglomerate, alternating with layers of massive, coarse, white sandstone, the whole mass being 50 or 60 feet in thickness. Fragments falling from the cliffs of this formation lie scattered about the gap and down the stream, but do not serve to trace it further than half a mile towards the N., or than Lyberger's

Run in the opposite direction. Not far below it in the series we see, opposite the mill, olive slates and beds of sandstone dipping 35° N. 60° W.

S. of Lyberger's Run, the Cadent and Vergent hills are frequently cut away, but rise again towards the Big Wills' Creek. Along a stream which enters this creek from Savage Mountain, the strata are all vertical, affording a good opportunity for measurements. The thickness of the Cadent and Vergent series is here between 800 and 900 yards. On Thompson's Run also the rocks are vertical, the "strike" being N. 35° E., and S. 35° W.

Gladding's Run gives good exposures of Cadent and Vergent olive slates and sandstones all vertical. At Mr Comp's house the upper part of the series is exhibited for a distance of 290 yards in the following descending order :—Olive sandstone, thin-bedded ; Olive sandstone, massive, interstratified with slate ; Sandstone, buff and brown, thin-bedded, interlaid with olive slate. Other exposures of olive slaty sandstone occur at intervals of 300 yards, 75 yards, and 500 yards ; after which we come upon black slate.

The anticlinal axis in the Cadent and Vergent rocks, which has been described as dying out at the State line, allows the Cadent black slates to fold across it, as seen at Jenning's Run in Maryland. But all the Cadent and Vergent rocks above the black slate continue at the surface to be vertical. Here may be seen, near Mr Buchanan's house, an instance of the well-known curious wrinkling of one argillaceous stratum between two others, or between two sandstones lying perfectly flat and undisturbed.

Ponent Series.—The anticlinal region between Savage Mountain and the Alleghany Ridge is occupied by very lofty hills, almost as high as either mountain. The Ponent sandstone forms the lower slope of both mountains, as well as the two ranges of hills at the base of each, allowing an arch of Cadent and Vergent rocks to appear along the axis in the transverse valleys.

At its N. termination the Savage Mountain is composed almost wholly of the Ponent rocks, the top alone being capped by Vespertine conglomerate. But an inner concentric crest rises behind the knob along the outcrop of the seral conglomerate. The older Ponent rocks form a range of high hills encircling the end of the mountain, and these are cut by transverse valleys opening into the valley of Little Wills' Creek. In these the lower red shales and brown and grey micaceous sandstone of the series are the rocks usually exposed.

The upper part of the Ponent series forms the slope of Savage Mountain on the E. side ; while the lower portions form, with the Vergent grits and shales, the high ridge along its foot, a few sections of which are afforded by the exposures in the gaps.

Where Wills' Creek breaks through the E. line of Savage Mountain, the latter rises in a vast knob overlooking all the country. Its top is formed of white quartzose conglomerate, with pebbles as large as peas in a white silicious cement. Within the mountain is the Frostburg coal-basin. A section across the Wills' Creek Valley is given in this diagram.

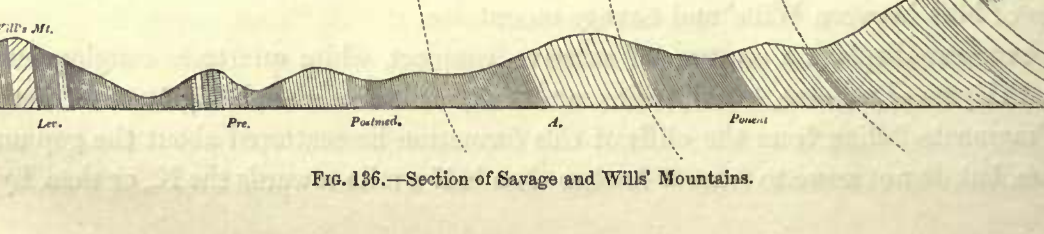


FIG. 136.—Section of Savage and Wills' Mountains.

From Wills' Creek Gap to Maryland, Savage Mountain is called Little Alleghany Mountain, and is a straight and regular ridge, much lower than the knob described at the gap. The gorge of Gladding's Run alone reaches it.

The seral conglomerate stratum is not seen in place in Wills' Creek Gap, but its fragments fill the bed of the stream as it issues from the Frostburg basin.

On Thompson's Run the alternations of Ponent, Cadent, and Vergent rocks are again seen in vertical posture.

On Gladding's Run, in the gorge of the mountain at Emmerick's Mill, a massive conglomerate dipping 30° N. 60° W. is to be seen. Below the mill there is an exposure for 300 yards of coarse white-and-grey sandstone, irregularly stratified, massive, and dipping gently N. 60° W. In it lies a bed of black slate. It is probably the Vespertine conglomerate. Another exposure occurs one-fourth of a mile below the mill ; beneath it are red flagstones, and at one-fourth of a mile further are Ponent red sandstones, dipping perpendicularly, and exposed for 70 yards. Again, 300 yards below the last occurs an equal thickness of the same red rocks, and 200 yards below this, other red shales and brown thin-bedded sandstones, dipping vertically, and exposed for 160 yards. Cadent shales occur 400 yards below the preceding. Umbral red shales appear on the mountain-side, near the summit, 3 miles S. of Gladding's Run, on the road from Cumberland. Thus, in this vicinity, the Seral conglomerate forms the crest, as the Vespertine conglomerate constitutes the summit elsewhere.

An admirable suite of vertical exposures of the Cadent, Vergent, and Ponent series, 1400 yards in length, is presented by Jenning's Run.

BOOK VII.

SEVENTH OR NORTH-WESTERN DISTRICT.

We come now to consider the Geology of the N.W. corner of the State, embracing the whole of Erie, a large part of Crawford, and the N. half of Warren counties. This is much the simplest of all the natural divisions of the geological surface of Pennsylvania, as respects both the variety of its strata and their structural features. It includes, in fact, only two of our Palæozoic formations, namely, the Vergent flags and Vergent shales. These strata retain very nearly the horizontal position in which they were originally deposited, having, in the general broad lifting of all the Appalachian basin, sustained a very trivial inclination or dip towards the S.E., which extends to the coal strata, and gives them their trough-like configuration. No anticlinal undulations, having a more than barely perceptible degree of flexure, modify this gentle S.E. declension of all the rocks. The district is therefore not naturally subdivisible, and as its strata contain few or no mineral deposits of interest, it admits of being very succinctly described. A single Chapter will suffice for the exhibition of the more important general facts in its geological composition and structure.

CHAPTER I.

OF THE GEOLOGY OF ERIE AND CRAWFORD AND THE NORTHERN HALF OF WARREN COUNTIES.

Topographical Features.—The whole of this N.W. angle of Pennsylvania is but part of a far larger belt of country, identical with it in geological constitution and in general external features, which stretches N.E. into New York, and S.W. into Ohio, and borders the S.E. side of Lake Erie throughout nearly its entire length.

This extensive and very distinctly marked tract, composed of the N.W. broad outcrop of the Cadent and Vergent rocks, rising from beneath the great Appalachian Coal-Basin, has in Pennsylvania a mean breadth of about 40 miles. The entire belt, from Cattaraugus County, New York, S.W. to Sandusky Bay, presents the form of an inclined plane, descending with a long and gentle slope towards the lake ; but this slope consists rather of a succession of low terraces, themselves a little inclined, than of one continuous gradual slope. These terraces are parallel with the lake coast, and are formed by the outcropping strata. From the S.E. margin of the tract, the whole descent to the lake side is between 1300 and 1400 feet, so that the average inclination of its surface is about 33 feet to 1 mile. This declivity is sufficient to furnish many wide and pleasing views of portions of the great slope, and of the distant lake; and along the general terrace or terraces which form the water-shed of the streams entering the lake, the landscapes are particularly beautiful. From the high ground 8 or 10 miles from the lake, the downward sweep of the surface is somewhat rapid; the terraces below are numerous and well defined; the coast of the lake itself is seen, and its vast plain of pure blue water fills the wide distance of the always impressive picture.

An additional variety of feature is imparted to this broad slope, by a series of deep and wide transverse valleys, descending S., which trench all the N. border of the high plateau of the Coal region, and convey the streams, flowing from the Lake Erie water-shed into the Alleghany and Ohio rivers, across the higher Southern portion of this plain, from the slope towards the Lake. These valleys have evidently been carved by a tremendous rush of waters, and the date of their first excavation was probably coincident with the drainage of the Appalachian Sea, when the mountain ridges and plateaus of Pennsylvania were uplifted, and a portion of the retreating floods swept N. into the less elevated region of the Lawrentian lakes. Subsequently, however, they must have given passage to that almost continental inundation, which, coming from the far N., poured its last expiring currents against the N. slopes and table-lands of Pennsylvania and Ohio, deepening and opening these S. draining valleys, and strewing their beds and the escarpments facing the lake, with the water-worn fragments of the rocks ploughed up by its progress. All the N. tributaries of the Ohio river, from the Alleghany River to the Muskingum, with their innumerable head-streams, take their rise on the Lake Erie slope, and the greater part of them within a few miles even of the lake; and they flow S. through these valleys into the Coal-basin, the S. dip of the strata exercising apparently more control over the direction of the drainage than does the mere inclination of the surface.

Along its entire S.E. border, this Lake Erie slope is bounded by the abrupt, low, broken wall or escarpment, which constitutes the verge of the bituminous Coal region. There the massive strata of the Seral conglomerate, and Vespertine sandstone, emerging from under the Coal-measures, form a greatly indented table-land, ending in a series of platforms and insulated or outlying plateaus projecting N. into this district. This escarpment is nowhere very elevated, for the Seral conglomerate, elsewhere along all the S.E. coal-fields a thick, coarse, and resisting formation, is, in this its N.W. outcrop, only a rather coarse and loosely-cemented sandstone, retaining a few scattered pebbles, and scarcely exceeding 100 feet in thickness.

This whole Northern edge of the Coal region—between the Clarion and the Tionista, and also extending across the river S.W. towards Mercer and Beaver—consists of an undulating and slightly-broken surface, rising gradually towards the N.W. The deep valley of the Alleghany crosses it transversely, following the dip of the strata. All the larger streams which empty into this river below Franklin, fall in upon the E. bank, and do not appear to be influenced by the strike or dip of the strata. French Creek, Oil Creek, and the Brokenstraw Creek, are the only considerable streams entering it upon the W. side: these have their sources in Crawford and Erie counties, and follow the dip of the strata nearly throughout their course.

The rise of the Alleghany River, from Pittsburg to Franklin, does not exceed 755 feet, and the rise of French Creek from its mouth to Meadville is about 130 feet. The highest hills in the neighbourhood of Meadville are more than 500 feet above the bottom of the aqueduct, and the general level of the tops of the hills between it and Warren, or rather between it and the mouth of the Brokenstraw, cannot be much, if any less, while to the S.W. there is a gentle falling-off in the general level of the country. The Shenango at Sharon is a little more than 230 feet above the mouth of the Alleghany at Pittsburg. Lock No. 12, at the bend of the Shenango, is about 255 feet above the Ohio at the same place, and the general level of the tops of the hills cannot exceed 350 feet above the bottom of Lock No. 12.

This belt of country, extending from Warren through Meadville, to the bend of the Shenango, marks the limit of the more broken topography, characteristic of the Coal formation, the tops of only the higher hills being capped by the lower sandstone of the Coal-measures. Beyond this towards Lake Erie the country presents, for some distance, an undulating surface, upon nearly the same general plane; the hills, though sometimes isolated, do not rise high, nor are the valleys deeply excavated. The plain ascends gradually towards the N. and N.W., until it reaches the high dividing ridge which separates the waters of the Alleghany tributaries from Lake Erie. This ridge crosses the New York State line near Colt's Station, where it is about 1000 feet above the surface of the Lake. It then passes in a straight line to Strong's Turnpike Gate, 10 miles from Erie, where it is from 850 to 875 feet above the Lake level. From Strong's, South-westward, it becomes less distinctly marked, and much depressed, and is altogether lost previous to reaching Conneaut Creek. The summit of the Erie Extension Canal is at Conneaut Lake, and is little more than 500 feet above Lake Erie. The descent from the summit of this dividing ridge to the waters of Lake Erie is made by four tolerably well-marked terraces, which run nearly parallel to the margin of the Lake. These terraces are higher and better defined as we approach the New York State line, and become much depressed on reaching Elk Creek and Fairview townships, with the exception of the lower one, which extends into the State of Ohio. The streams which empty into the Lake frequently run within one of these terraces for a considerable distance before they find an opening, through which they can pass to a lower level: thus Walnut Creek, Elk Creek, and Conneaut Creek, head very far to the E. of their respective final outlets.

Formations of the North-western District, and their Local Composition.—As already intimated, the rocks of this region appertain exclusively to the Vergent flags and Vergent shales. The reader will comprehend without difficulty the simple geological composition of the district, if, after a glance at the geological map of the State, and the North-western portion of Section VIII., he bears in mind that, with a very gentle S.E. dip, not more than 15 feet to the mile, there is necessarily a N.E. and S.W. trend or strike in the outcrop or margin of the strata. A moment's inspection of any general geological map of the United States, showing the Lake Erie region, indicates that the course of the Cadent formations must be through the Lake, entering it in their range S.W., between Buffalo and Cattaraugus, and emerging from it between the Vermilion River and Sandusky Bay. These lower Cadent rocks bound, of course, the outcrop of the Vergent flags, and therefore one-half of even this formation must lie within the Lake, its North-western margin sweeping in a convex curve from Cattaraugus to Vermilion River. Between these points the whole Lake coast displays only the upper or sandstone member of the Flag formation, called in the New York Geological Survey the Portage sandstones. This group of strata, crossing Erie County, Pennsylvania, in a S.W. direction, almost precisely parallel with the trend of the Lake coast, constitutes a belt 10 or 12 miles in width, its upper limit pursuing the general water-shed of the district. All the rocks between this line and the margin of the coal-field are referable to the Vergent shales ; for neither the great Umbral deposit, nor the Ponent series, shows a trace of its presence along the N.W. outcrop of the Seral conglomerate and Vespertine sandstone. Both of these elsewhere important formations were creations of a shallow sea, into which they were brought by Westward-setting currents, and therefore, as land-derived sediments, they thinned entirely away E. of the outcrops of the Cadent and Vergent strata, or the N.W. margin of the great bituminous Coal-basin. The Umbral red shale in a more Southern latitude alters its character to a fossiliferous limestone, and in that condition spreads indeed widely to the W.

The Vergent flag or sandstone formation, in the type which the group wears upon Lake Erie, would not be recognised in its lithological composition, by those who are only familiar with it in the Appalachian valleys. Near the lake, and in the Eastern and central tracts of New York, the whole formation is far more arenaceous, and the proportion of the sandstone layers to the shales, or more purely argillaceous beds, is much greater, the upper or terminal subdivision of the mass, especially, containing with a large amount of thin-bedded or flaggy sandstone a considerable body of more massive strata. But advancing W. the clayey element predominates, and in the belt of country bordering on Lake Erie but comparatively little true sandstone remains in the mass. The most arenaceous portion of the formation is even here near the top ; and where well exposed, as it is in several places about 8 miles S. of the lake, where it is occasionally quarried, it may be recognised by its characteristic marine vegetation, and especially by a vertical stem-like form or species of Scolithus.

The Vergent shales have undergone a similar change to that experienced by the preceding group, losing much of the little arenaceous matter they possess in more E. and S.E. outcrops, and becoming more exclusively argillaceous. This group being even in the Appalachian valleys a body of grey, greenish, and blue shales, with only occasionally interposed beds of rather coarse grey argillaceous sandstone, its alteration of type is less obvious than that of the other. The Vergent flags, by acquiring an almost entirely argillaceous character, approximate so nearly in composition to the overlying Vergent shales, that a separation of the masses into distinct formations is no longer practicable ; and in the district before us, besides being attended with no utility, would be at variance with sound principles of geological classification. These two subdivisions of the Vergent series, as I have generally viewed them, are, it must be observed, nowhere very clearly separated, either by their constitution or their organic remains ; and it is particularly deserving of attention that even the fossils supposed to be distinctive of the two formations, and which locally are somewhat so in New York and in the Appalachian valleys of Pennsylvania, become more mingled as we follow the strata W. into Ohio. It would seem that, from the close of the Cadent upper-black-slate to the end of the Vergent upper-shale periods, there prevailed an enormous area in the Appalachian ocean, presenting nearly one unchanging condition of sedimentary deposition. The slight oscillations in the energy of the marine currents, and consequent coarseness of the materials derived from the shore, were less felt far out in the waters towards the W., and the tribes of molluscs and other marine creatures, organised in adjustment with the state of the ocean's bed, were there unmolested by the changes which disturbed them nearer to the land ; and which there led to the substitution of other species. A careful and extended survey of the geographical and stratigraphical, or horizontal and vertical distribution of the organic forms imbedded in the Cadent and Vergent strata, leaves us in no doubt as to the applicability to these rocks of the universal law, that species are typical of strata only to the limit that the strata themselves are typical of the physical conditions favourable to their special development, and that in proportion as the strata show proofs of the introduction of other physical circumstances during their deposition, whether upon the same horizon or in the order of time, other races invariably appear, and some of the old ones as invariably pass away. Thus, then, there can be no universally characteristic fossils ; and each species or small group of species is only locally—if we view the entire surface of the globe—typical of any formation, or of any portion of geological time. We have an instance of this, I think, in some of the so-called characteristic fossils of the Vergent flags, or Portage group of New York. In the able volume on the geology of the W. district of that State, by Professor James Hall, a beautiful little shell, the *Avicula speciosa*, is said to be distinctive of this group, and to be known in no other rock. This delicate fossil may be thus restricted in New York, but it is by no means confined to the formation elsewhere, for in the region of the Potomac River it occurs very abundantly in an inferior formation, the Cadent upper black slate, or Genesee slate of New York, and, if I mistake not, is to be seen in the highest Vergent strata in the Western States.

Thickness of the Formations.—Between the level of Lake Erie and that of the base of the coal-rocks, the rise, as already mentioned, is from 1300 to 1400 feet ; but this difference does not embrace the entire thickness of the strata, which dip on an average about 14 or 15 feet to the mile, for a space of 40 miles, and must therefore possess an additional depth of about 600 feet. The whole Vergent mass is therefore, at the least, 1900 feet thick. About 800 or 900 feet will probably represent the thickness of the lower formation, the Vergent flags, and 1000 or 1100 feet that of the overlying Vergent shales. The quarries near the road, between Waterford and Erie, at an elevation of 800 feet above the Lake, indicate nearly the highest portion of the inferior group. It would appear, from the researches of Professor James Hall, that the total thickness of the Vergent flag formation, or Portage group of New York, amounts in the longitude of Chautauque Creek to nearly 1400 feet ; we are therefore to infer, that in the region of Lake Erie some 500 or 600 feet of the formation are covered by its waters.

Assigning to the upper division of the Vergent series a thickness of 1000 or 1100 feet, and comparing these dimensions with its magnitude in the Appalachian Chain, we become aware of the important contraction which the formation experiences as it spreads towards the W. and N.W. We have seen that it measures in the vicinity of Catawissa 3150 feet, and at Huntingdon 3200 feet. On the Genesee River, nearly as far to the N.W. as Crawford County, its bulk is somewhat greater than in the latter region, and, according to Hall, both the Cadent black-slate and Vergent groups taken together embrace in the State of Indiana a thickness of less than 400 feet. From this latter statement we are not to infer that the direction of maximum change of thickness is from E. to W. An extensive examination of the series proves, that while the whole mass and all the more arenaceous subdivisions undergo a steady but gradual reduction of thickness in spreading S., they experience a much more rapid diminution in the N.W. direction. For example, at

Bean's Station in the N.E. part of Tennessee, a point nearly S.E. from the locality in Indiana alluded to, the entire Cadent and Vergent series measures nearly 1500 feet, and the upper or Vergent shales are there 750 feet in thickness. The distance from Bean's Station to the Cadent and Vergent rocks N.W. of Louisville, is, however, only 218 miles in a direct line; and in this distance, the upper formation—the Vergent shale—declines to about one-third its magnitude. Again, between Huntingdon and Crawford counties, Pennsylvania, the interval is a little more than 160 miles, and in this space the deposit thins away in the same or N.W. direction, also to one-third its bulk. Now in the other or S.W. direction—parallel, that is to say, with the ancient Appalachian shore—the distance from Huntingdon to Bean's Station is about 430 miles, and between these places the formation wanes to about one-fourth of its maximum size, and the whole Cadent and Vergent series to a little less than one-third. About 320 miles in a S.W. direction are here equivalent to a diminution of the Vergent shales to one-third, whereas in a N.W. one, from 160 to 210 miles suffice for a similar reduction. It is obvious from these data that the great current, in flowing coastwise from N.E. to S.W., gradually expanded as it abated in energy, and spread Westward, or into the deeper sea, carrying thither only the lighter, more buoyant particles. We can hardly resist the conjecture that it was a great systematic current, resembling, perhaps, the modern Gulf-stream in the feature just alluded to, and like it maintained, for an immensely long period, as a component part of some grand circulation of the earth's waters, regulated by permanent physical causes.

Features of Deposition, Concretionary Structure, &c.—Little need be added in this place to the descriptions already given in Book IV., and elsewhere, respecting the internal structural phenomena of these rocks.

The ripple-marks, so abundant further towards the E. and S.E., especially in the Vergent flags, are numerous even in Erie and Crawford counties; but, nevertheless, like all the other indications of activity in the waters precipitating these sediments, they show a decided diminution in that direction. Their occurrence at so remote a distance from the nearest margin of the then dry land is a circumstance of much theoretical interest. Were these unequivocal signs of undulation in the waters produced by the wind, and the surf-ripple over extensive shoals, or did they originate in comparatively deep water by an oscillatory motion in the silt-bearing currents, occasioned by the friction of the bottom? That so large an area of the Appalachian sediments should have been maintained so precisely at the sea-level, for the vast time implied, and during a prolonged subsidence and filling-in of the bed of the waters, to the extent of the entire Cadent and Vergent series, or to at least one vertical mile, seems, with the facts which we have to reason from, extremely difficult of admission.

Diagonal lamination, or false-bedding, indicative of a steady and somewhat rapid flow of the current along their bed, is a feature of many of the more sandy layers in the strata of this district, but is less conspicuous than where the rocks are more arenaceous further to the S.E. and E.

Concretions of various shapes abound in the more calcareous varieties of the finer-grained clay-shales, particularly those of the lower or flag group. The commonest forms are spheroids, generally much flattened, and often curiously lobed by the addition of fresh materials on one or more sides. When very calcareous, these are seamed with little veins of carbonate of lime, filling cracks in the more central portions; they are, in other words, true *Septaria*.

Among the concretionary structures is one form which, from its singularity, and the doubts entertained by many in relation to its mode of origin, deserves a more special mention. It is the so-called "Cone in cone" structure of the English geologists. In England it is met with occasionally in the finer shales and clay iron-stones of the Coal-measures; but in our vast series of formations I have seen it nowhere but in this particular horizon near the Vergent flag formation.

It usually occurs in flat cakes of hardened calcareous shale imbedded in soft mealy shale, the conical structure occupying a thickness of 1 or 2 inches on one surface of the cake. Its position in the strata is near the Lake Shore; and perhaps the best localities for it in Erie County are at the mouth of Sixteen-Mile Creek, and at the Cascade near Erie; but it is to be seen in a corresponding situation bordering the lake, at a great number of spots, throughout the entire length of the formation from Chatauque Creek in New York to Cleveland, Ohio; and Professor Hall speaks of it as abundant on the Genesee River.

CHAPTER II.

ECONOMICAL AND OTHER DETAILS.

A MINUTE inspection of the strata whose thin edges are disclosed in the low cliffs of the Lake Shore in Erie County, and in the numerous deep and narrow ravines and water-courses which descend across their outcrops near the lake, will show them to consist, for about the first 200 feet, chiefly of blue and olive-coloured soft calcareous clay-shales, brown bituminous shale and slate, and their alternating layers of fined-grained grey calcareo-argillaceous sandstone. All these materials are in thin beds, and in constant alternation, their dimensions being from one-fourth of an inch to 12 inches. The carbonaceous shales and slates are the thinnest. Some of the finer-grained shales extend with little change of thickness over very considerable areas, while other beds change their dimensions rapidly. The shales, but more especially the sandstones, are slightly calcareous.

The level line of the shore enables us to detect, in the dip of the strata, a slight lateral or N.E. and S.W. undulation; but this feature is only local and inconspicuous. At the mouth of Elk Creek, and elsewhere, the strata exhibit even a very gentle dip towards the N.W.; and when examined, this feature is connected with a low anticlinal arching of the rocks, the axis of elevation being near the bridge, half a mile above the outlet of the stream, not far from Gerard. If it were practicable thus to refer all the inclinations of the strata to a succession of horizons absolutely level, we should discover, I doubt not, a vast succession of very low but broad and obscure anticlinals, conforming in their N.E. and S.W. trend to the flexures of the Appalachian Chain, and indicating the last expiring swells in the crust, transmitted with abating intensity across the broad bituminous Coal region, from the enormous billows which lifted the Appalachian Chain.

Organic remains are rare in the strata near the side of the lake, but one slender layer, about 3 inches in thickness, occurring on the shore near the village of North-East, contains the little *Avicula speciosa* and *Ungulina suborbicularis*, the most abundant fossils of the formation. In other places the faces of the slabs of slate, especially when in contact with bituminous shale, are sometimes covered with fragments of plants, chiefly a delicate species of fucoid.

Building-stone.—Ascending S.W. from the lake coast, we pass over a succession of more or less distinct terraces, making, in a distance of 8 or 10 miles, a rise of 600 or 700 feet, and crossing over about 800 feet thickness of strata. These terrace outcrops consist of thinly-laminated olive and brownish shales, alternating with flaggy layers of sandstone. These latter become gradually more abundant as we ascend in the series. The thickest arenaceous beds measure in some places 12 or 15 inches, and where a number of them occur together, with only thin partings of shale, the mass is quarried as a building-material. A stratum of this kind appears about midway between Erie and Waterford, and has been quarried in an excavation known as Vincent's, about one mile W. of the turnpike, the materials from it being used in the Locks of the Erie extension of the Pennsylvania Canal. Other similar masses have been quarried in the vicinity of Elk Creek, and along the line of the canal. Elisha Smith's, E. of Gerard, and Crain's, near Crain's Mill, are two of the most extensive of these quarries. It is seldom possible to trace a particular stratum of the sandstone for any considerable distance, for the beds soon thin off, or deteriorate for economical uses by becoming too argillaceous, and thus they fade into the great body of the formation.

At an elevation of about 810 feet above the level of the lake, there appear in the vicinity of Waterford two or three thin layers of calcareous sandstone, abounding in marine organic remains, chiefly bivalve shells. These strata, easily recognised by the profusion of their imbedded fossils, are to be seen at Whiteman's, and also at Wilcox's, near the village, as likewise along the streams at the head-waters of Le Bœuf and Elk creeks—one locality being near the house of Captain Strong. The species are characteristic of the Vergent newer shales, the Chemung group of New York.

Upon these fossiliferous beds rest several bands of sandstone, the layers being from 6 to 12 inches thick. These have been quarried for building-stone, but approaching Waterford they deteriorate. E. of the village occurs a stratum of yellowish sandstone, coarser than the beds of the formation generally, and differing from them in aspect. It has been quarried on the borders of French Creek, where a good building-material was obtained. At Smith's Quarry the bed was about 4 feet thick. Upon it rest first, thin bands of pebbly rock, the pebbles having the size of large shot; secondly, shale; thirdly, two layers of hard silicious sandstone, 16 inches thick, and above them slate and flaggy sandstone. A similar section may be seen on the opposite side of the stream at A. Middleton's.

In the Moravian Quarry the sandstone bed is not so thick. At Carrol's Quarry it is from 4 to 6 feet in thickness, some thin layers of pebbly rock or coarse grit and other sandstone resting over it, separated by only a few inches of shale. All these beds are embraced within a thickness of 10 or 12 feet. A little Petroleum is found in all of these quarries. We have already seen that many of the clay-shales are highly bituminous.

The general succession of strata enumerated in the foregoing paragraph extends over the whole of Erie and all the northern portion of Crawford counties. In the latter district the series embraces, near Conneaut Town, a thin bed of slightly calcareous sandstone, which was used in the construction of the Locks of the canal. The same bed has supplied other quarries between that place and Brightstown.

In the vicinity of Meadville, good natural sections are presented of a portion of the Cadent and Vergent series, the elevation from the level of the canal at the base of the hills to the bottom of the seral conglomerate amounting to 412 feet. Beds of brown, argillaceous, flaggy sandstone, alternating with bluish and olive-coloured shales, occupy the first 235 feet. Some of the interposed slates contain casts of fossils. At the above-mentioned limit, above the canal, an arenaceous limestone, similar to that of Conneaut Town, makes its appearance. It is only 2 feet thick, but has a remarkable horizontal extent, for it is seen 6 miles N. of Meadville, near George's Tavern, and again on Little Sugar Creek, and on French Creek. In Wayne Township it is more calcareous than elsewhere, and was at one time, by way of experiment, burned for the sake of its lime. A more than usually calcareous variety of it, at Keile's Mill, near Brightstown, was likewise burnt in kiln, but even this did not yield lime enough to render the attempt successful. At the same relative distance below the base of the seral conglomerate, this stratum may be traced in the hills around Franklin, also in Fallowfield Township, in Crawford, and on the Shenango near Greenville. It was also recognised by us in the hills about the bend of the Shenango, and near Sharon in Mercer County. It occurs as a layer not more than one foot thick, about 95 feet above the level of the canal Lock No. 15. Passing in a Southerly direction down the Shenango, it gradually approaches the level of the stream, below which it at last disappears, S. of Sharon. Spreading, as it thus does, over an area of 30 or 40 miles square, this stratum, considering its extreme thinness, is certainly remarkably continuous. At its outcrop it appears in large square blocks, almost invariably rounded at the corners by the corrosive action of the rain, which, by dissolving the carbonate of lime from amid the insoluble matters, has left these weathered masses encrusted with a brown ferruginous sandy covering to a depth frequently of one or two inches.

An inferior iron-ore is contained in the thick-bedded bluish sandstone beneath the limestone in the neighbourhood of Meadville. This ore, which is in thin plates, is too poor and too insufficient in quantity to be of any practical value.

Above the limestone rest beds of bluish-grey and brownish sandstone, with thin layers of calcareous shale containing fossils ; but these sandstones are not continuous, the acquisition of too much argillaceous matter impairing their value. A quarry on the road from Conneaut Town to Hartstown has afforded a good material for the structures on the canal ; and near Greenville the same stratum has been observed in more than one locality. Descending the Shenango, we find the bed wrought in a large quarry on Flute's farm, and again in places near Clarksville and Sharon. When this bed subdivides by accession of shaly matter, it merges into the surrounding shales and slates, and is not readily traceable. It may be recognised in the river hills around Franklin, and also higher up the Alleghany. For its economical value it is one of the most important of all the strata in the district, as building-materials of adequate durability are far from abundant in this belt of country. The thickness of this member of the formation is from 25 to 40 feet.

Above the sandstone, for a thickness of about 60 feet, we find laminated clay-slate and flaggy sandstones, with a few fossils. A little iron ore is frequently met with in this shale, as at Duncan's on Pymatuning Ridge, the vicinity of Little Sugar Creek in Wayne Township, and elsewhere. In Sandy Creek and French Creek townships the shale contains a considerable quantity of nodular-clay iron-ore. That of Rhodes' farm, 5 miles W. of Franklin, is of good quality. All the beds of shale in this vicinity contain more or less of the ore. It is not easy everywhere to define the upper limit of the Cadent and Vergent rocks, for throughout a considerable part of the N.W. margin of the Coal-field in Mercer and Crawford counties, these are not directly overlaid by the well-recognised Seral conglomerate or sandstone, but are divided from that formation, and are in contact with an inferior thin group of very argillaceous coal-measures, probably of the Vespertine age, which, destitute of coal, so entirely resemble them in their inferior beds that a clear horizon of separation is nowhere lithologically discernible, nor have we here the aid of Palæontological evidence, as these doubtful strata are generally destitute of organic remains. The thickness of the shales, to which this uncertainty applies, is, however, nowhere considerable, being seldom more than 30 or 40 feet.

Drift.—The greater part of the surface of the N.W. district is thinly strewed with Northern drift, and the valleys of all the principal rivers and streams are deeply filled with it, presenting some very instructive features in the forms of many bold terraces into which the waters have wrought it. The present Chapter is, however, not the appropriate place for the description of any part of this interesting formation, the full investigation of which I reserve for a separate subdivision of this work.

Character of the Soil.—The Cadent and Vergent rocks, of which this N.W. district consists, furnish by their disintegration a soil in which clay is the predominating ingredient. It may be denominated a cold clayey loam, better suited for grazing than for growing wheat. That derived from the inferior, more argillaceous strata, nearer the lake, is in many belts a stiff clay; while that into which the sandy matter of the upper parts of the formation enters as an element is looser, and approximates to the character of a loam. A greater or less mixture of the materials of the Northern drift, or transported gravel, with the proper soil of the region, modifies the quality of the latter, and gives to many localities agricultural peculiarities which the subsequent rocks themselves could never impart. In nearly all the larger valleys the depth of the drift is such as to confer on them a soil abounding in gravel. Though this very heterogeneous covering contains pebbles and sand derived from the limestones which outcrop to the N. and E. of Lake Erie, mingled with the less fertile materials of the crystalline and silicious rocks, yet further N., and with the fragments of the underlying shales, a soil exists usually well adapted to the culture of wheat and the finer kinds of grain.

The soil derived from the Cadent and Vergent rocks alone is too generally deficient in calcareous matter to possess a high degree of fertility, and, unfortunately for the domestic agricultural resources of the district, not a single bed or formation of good limestone, either within it or cheaply contiguous to it, contributes to the land the element which it chiefly needs. As, however, much good agricultural lime is procurable from the immediate coast of the lake towards its W. end, there cannot be a doubt that ultimately commerce, in her inexhaustible power to benefit, will be enlisted to convey the requisite quantity of this almost indispensable fertiliser not only to the coast of Erie County, but, by the canals, to all the contiguous regions towards the S.E.

Calcareous Marl.—In the Pymatuning and Conneaut swamps there are shallow but rather extensive deposits of a soft calcareous tufa and shell-marl, the possible value of which to the agriculture of the surrounding districts is not enough appreciated. Conneaut Lake, which is about 3½ miles long, and from 1 to 1½ miles broad, and in some parts 100 feet deep, is very shallow at its S. extremity. The largest deposit of marl is near Hamersville, about one mile N. of the N. end of the lake, in a swamp elevated about 15 feet above the present lake-level. Beneath a layer of decayed vegetation and moss—a kind of peat, in fact—lies the soft bluish-white clayey mass, a pebbly deposit of carbonate of lime imbedding innumerable minute fresh-water univalve shells, of the species ordinarily met with in the lake-marl of this description. This mass is in some places several feet thick, and has been converted into lime by being moulded into the form of bricks, and then burned in a small kiln.

END OF VOL. I.

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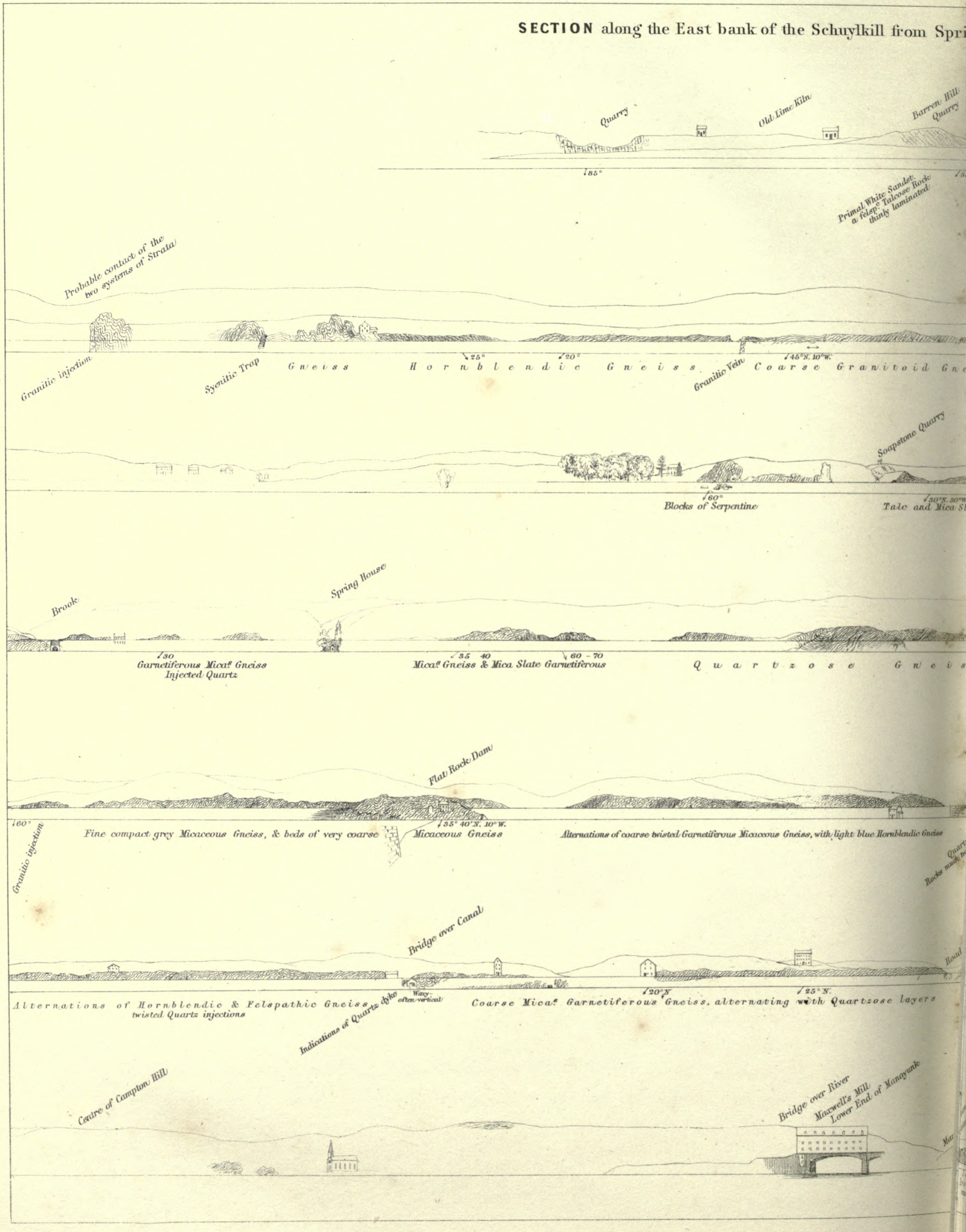
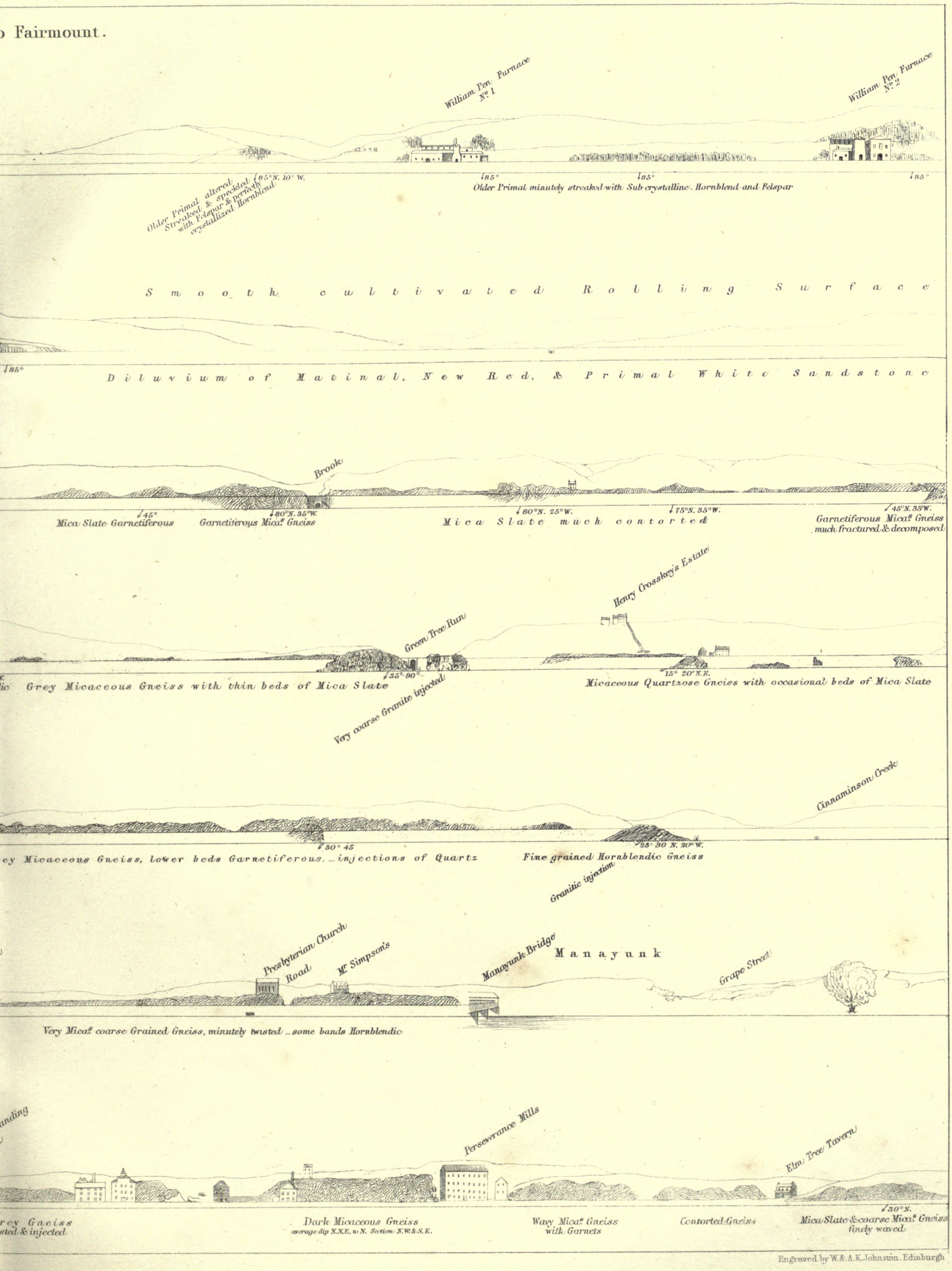

SECTION along the East bank of the Schuylkill from Spri
Quarry
Old Lime Kiln
Barren Hill Quarry
85°
Primal White Sandst. a felsp.c Talcose Rock thinly laminated
Probable contact of the two systems of Strata
Granitic injection
Syenitic Trap
25°
20°
45° N. 10° W.
Gneiss
Hornblendic Gneiss
Granitic Vein
Coarse Granitoid Gne
Soapstone Quarry
60°
Blocks of Serpentine
30° N. 30° W.
Talc and Mica Sl
Brook
Spring House
30
Garnetiferous Mica.s Gneiss
Injected Quartz
35 40
60 - 70
Mica.s Gneiss & Mica Slate Garnetiferous
Quartzose Gneis
Flat Rock Dam
60°
Granitic injection
Fine compact grey Micaceous Gneiss, & beds of very coarse
35° 40' N. 10° W.
Micaceous Gneiss
Alternations of coarse twisted Garnetiferous Micaceous Gneiss, with light blue Hornblendic Gneiss
Bridge over Canal
Road
Alternations of Hornblendic & Felspathic Gneiss
twisted Quartz injections
Indications of Quartz dyke
Wavy often vertical
20° N
25° N.
Coarse Mica.s Garnetiferous Gneiss, alternating with Quartzose layers
Centre of Campton Hill
Bridge over River
Maxwell's Mill
Lower End of Manayunk



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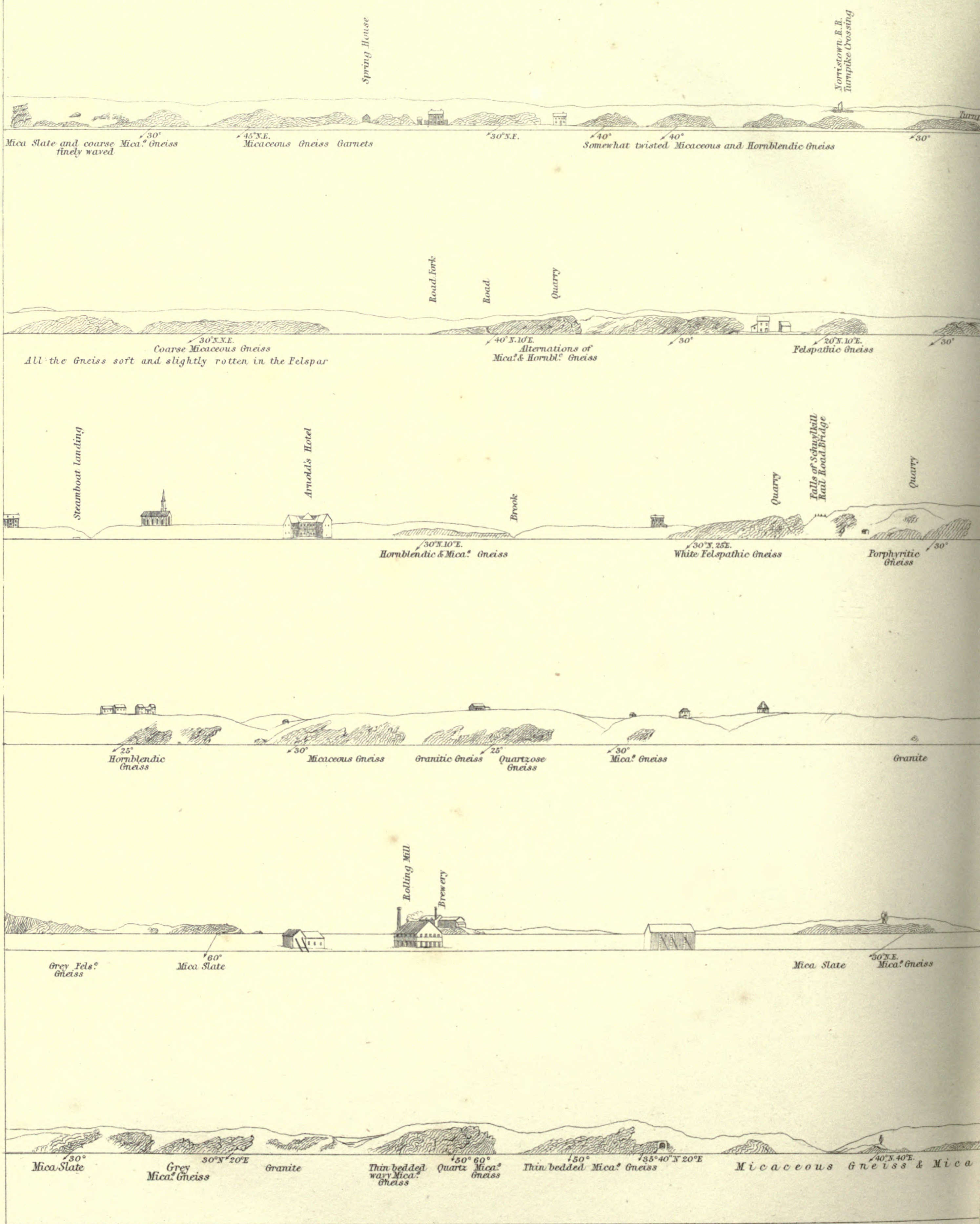
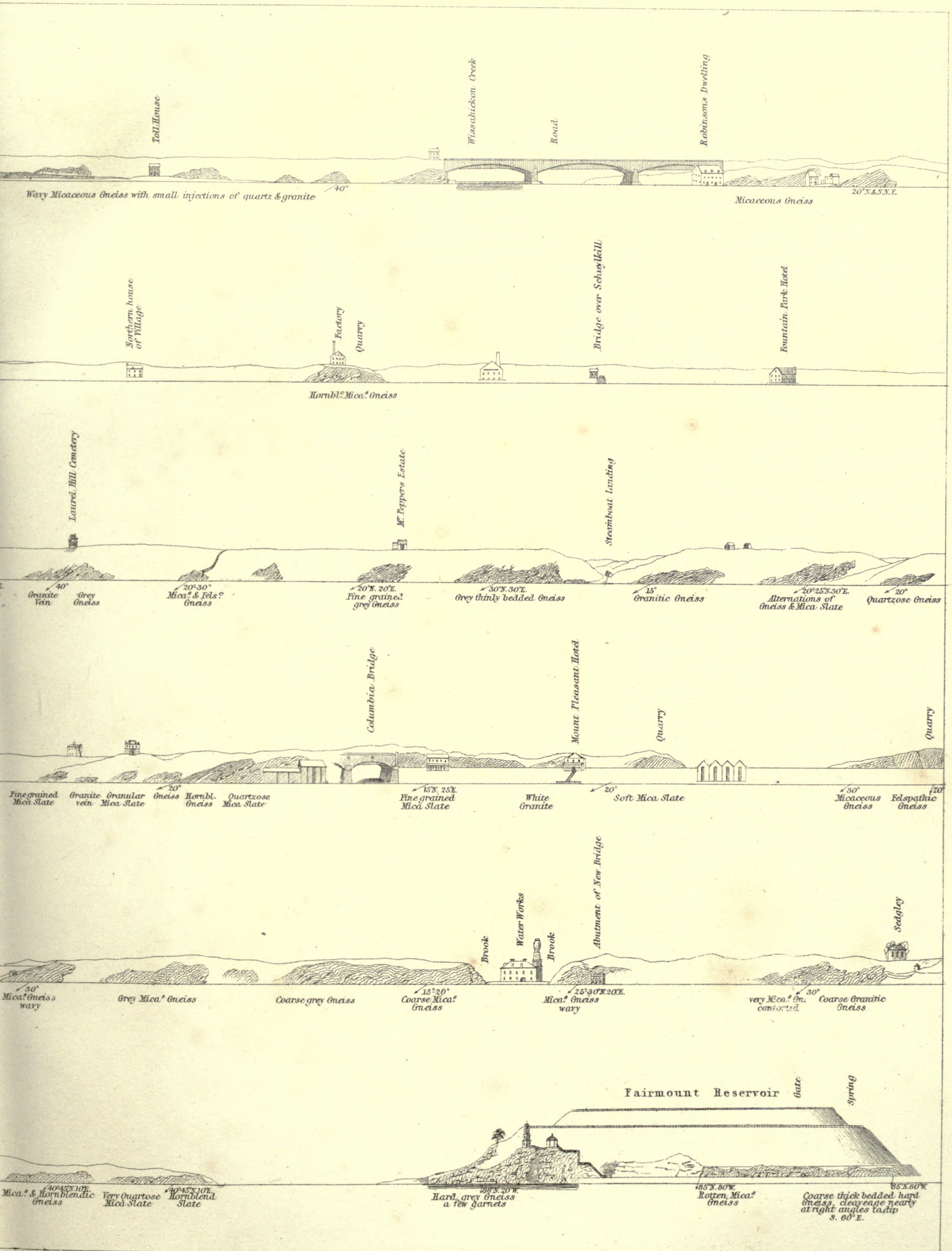
Continuation of Schuylkill Section.





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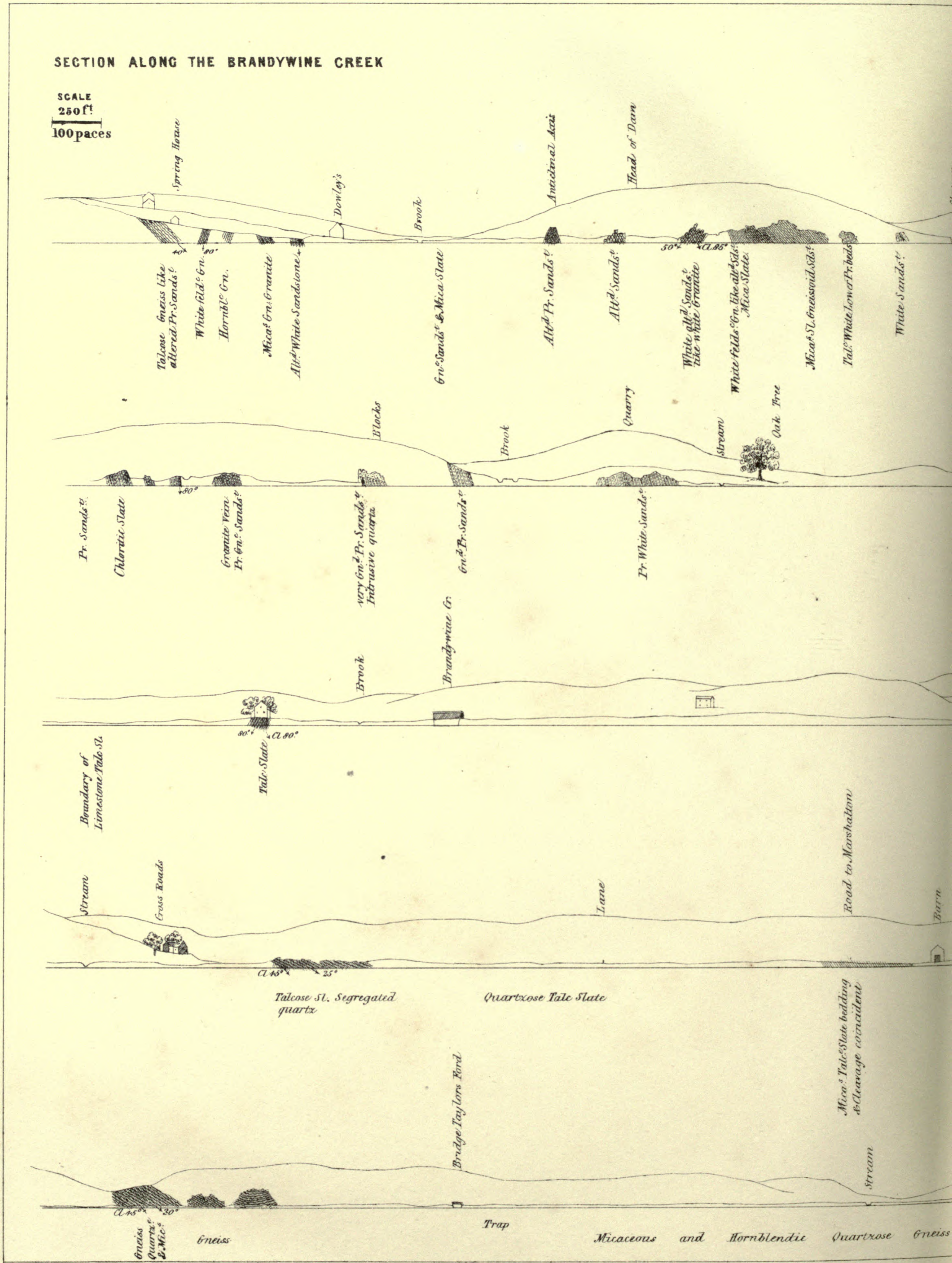
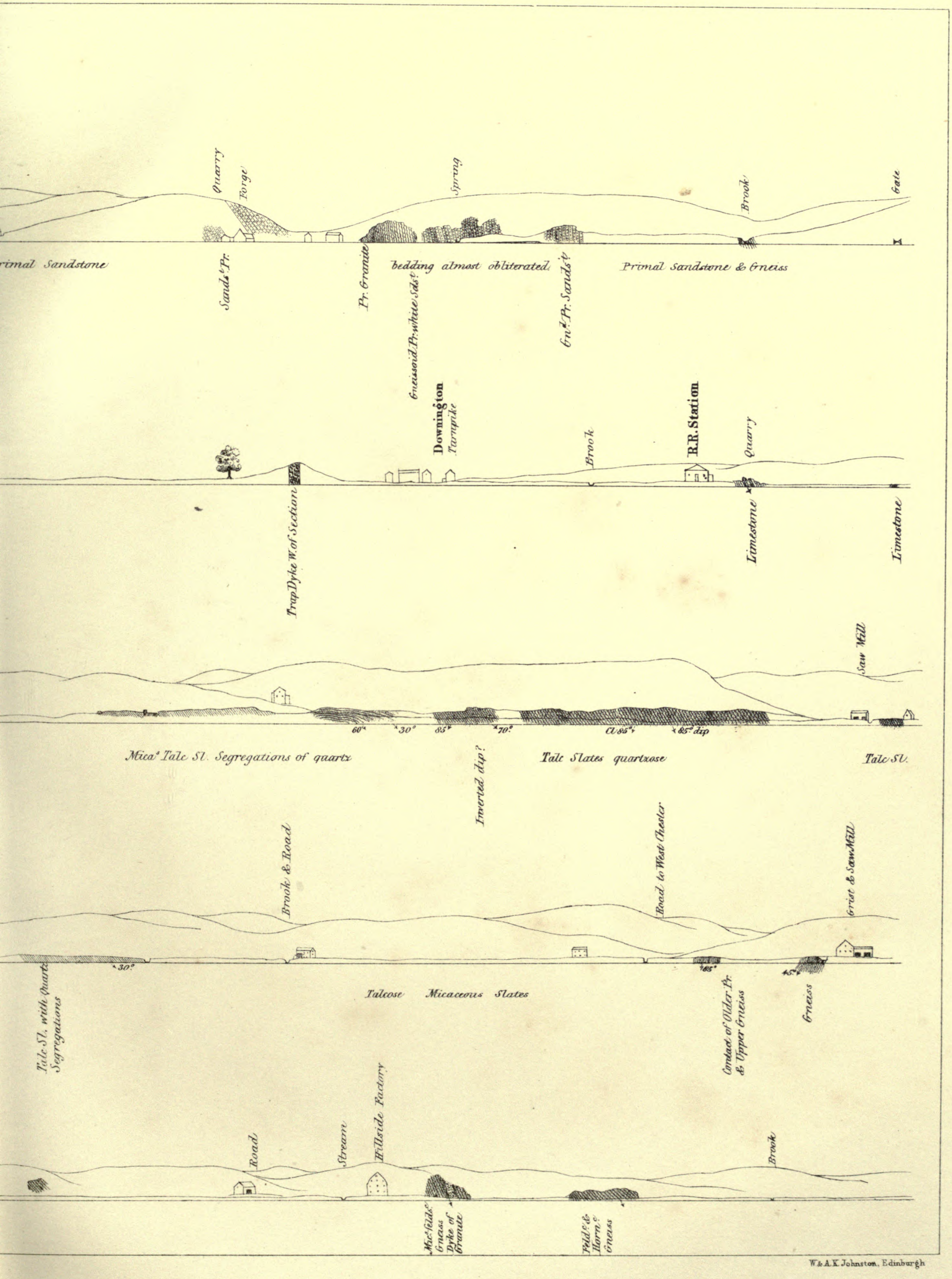
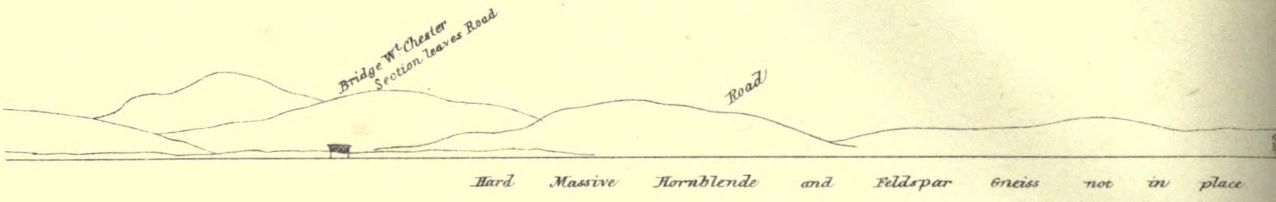


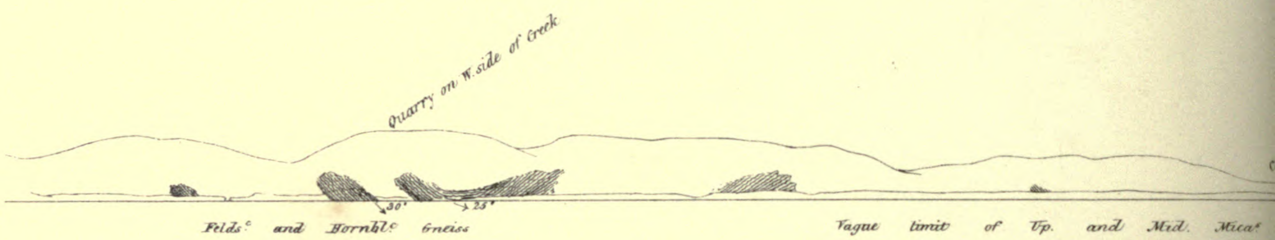
SECTION ALONG THE BRANDYWINE CREEK

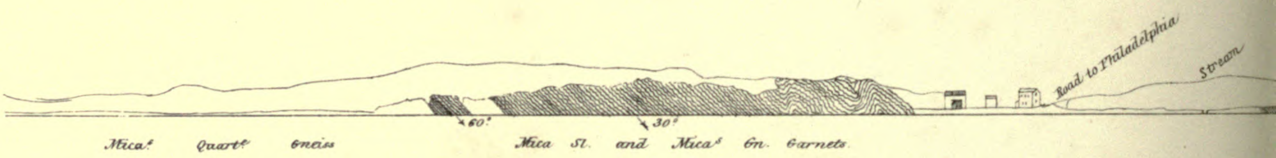


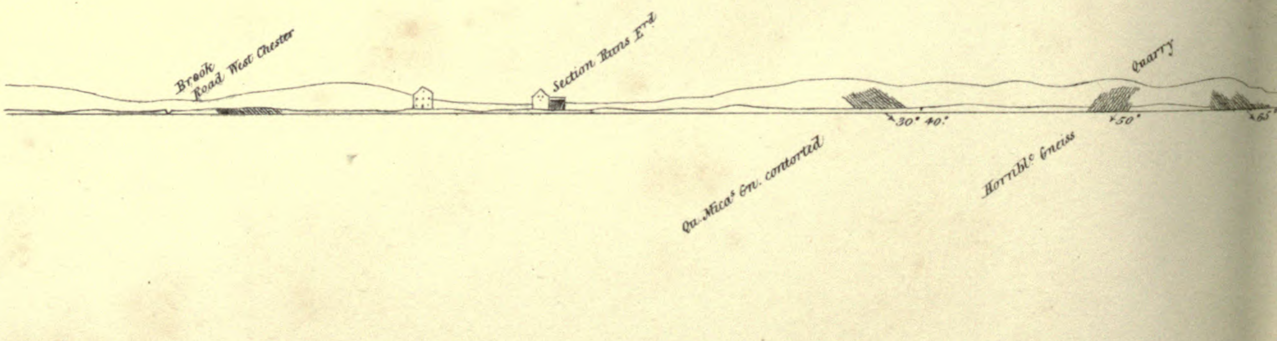
W. & A. K. Johnston, Edinburgh

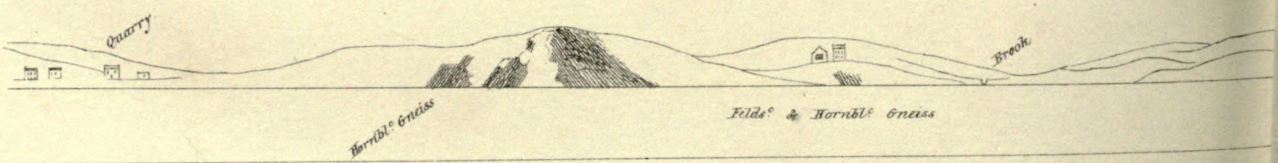
SECTION ALONG THE BRANDYWINE CREEK CONTINUED

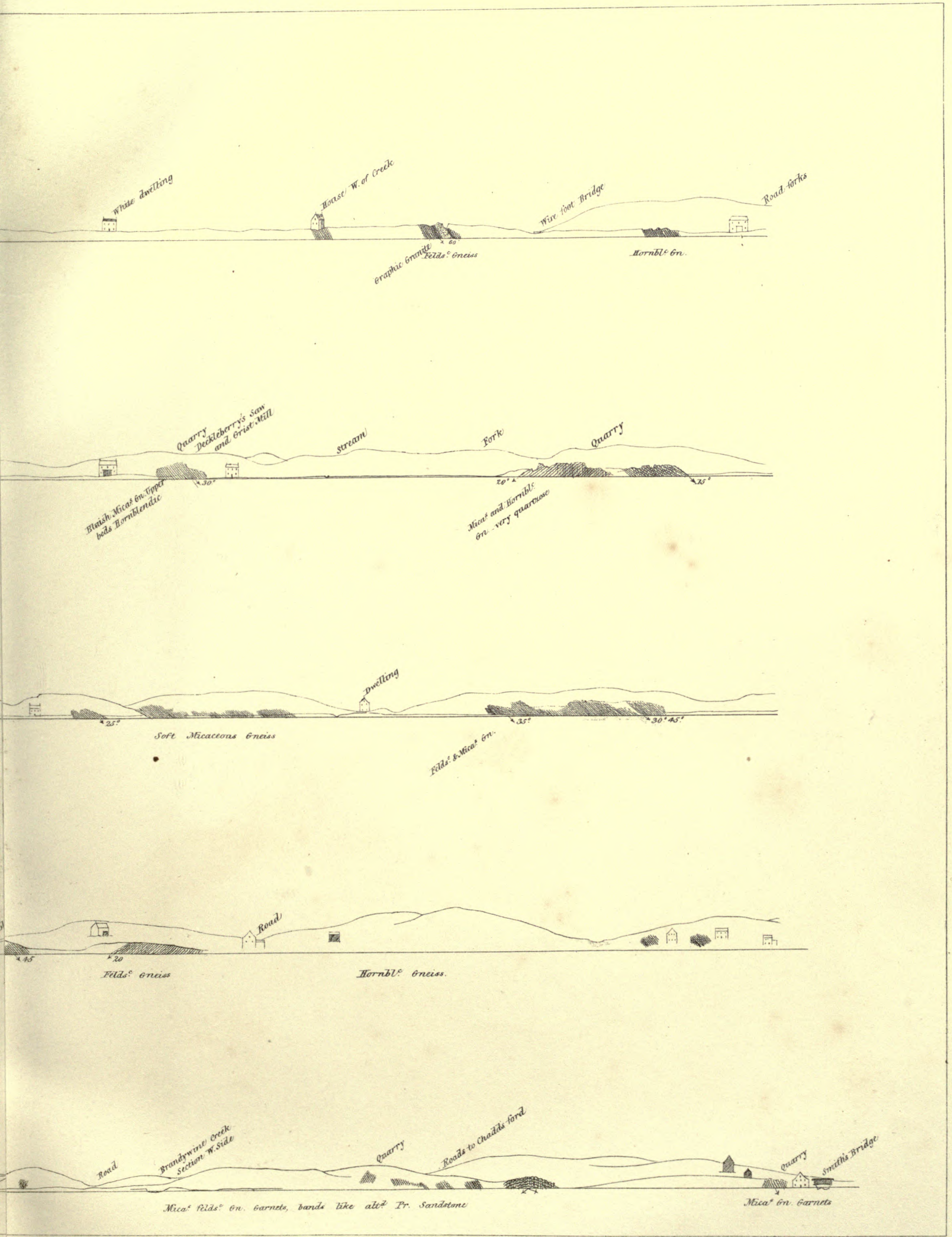












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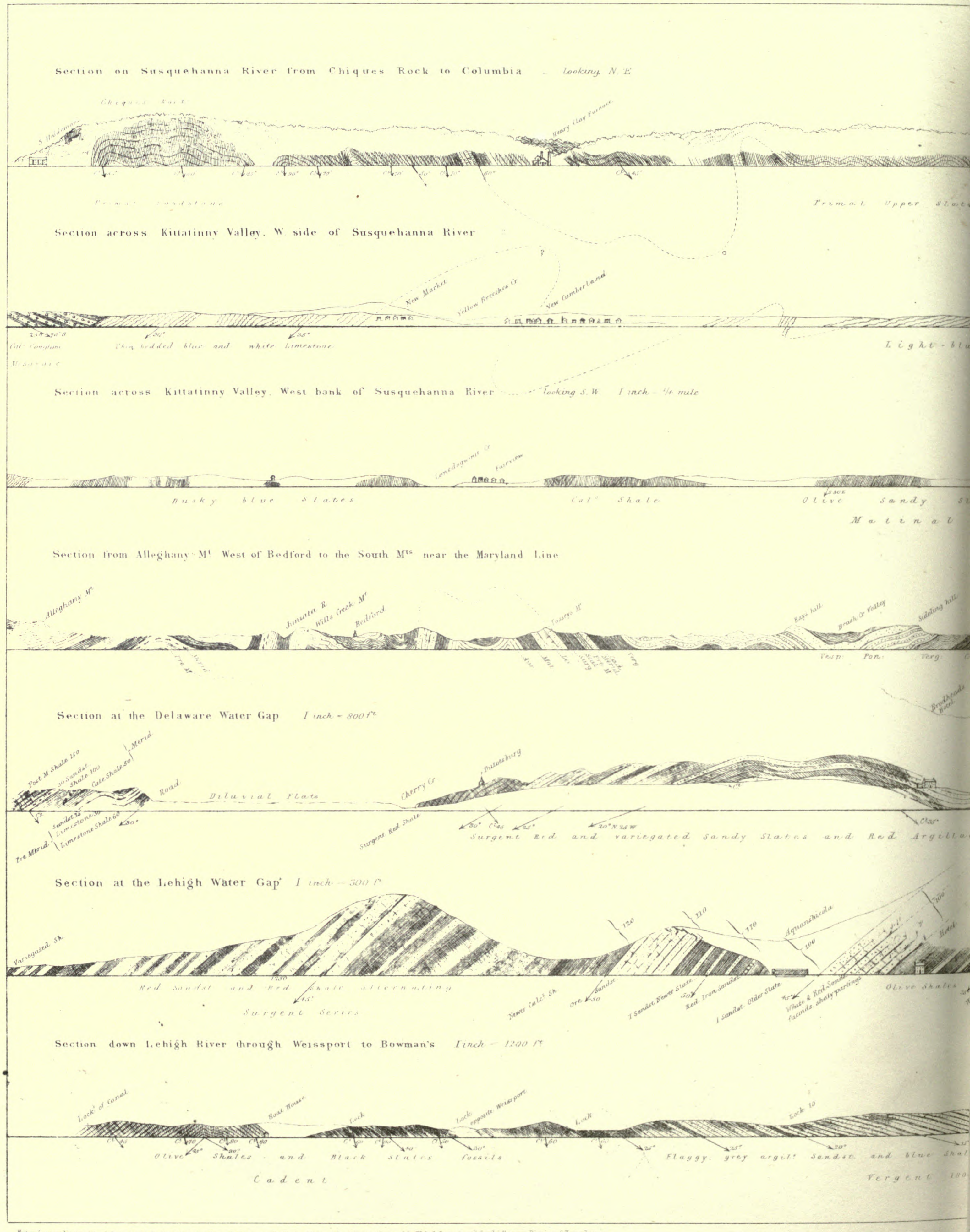
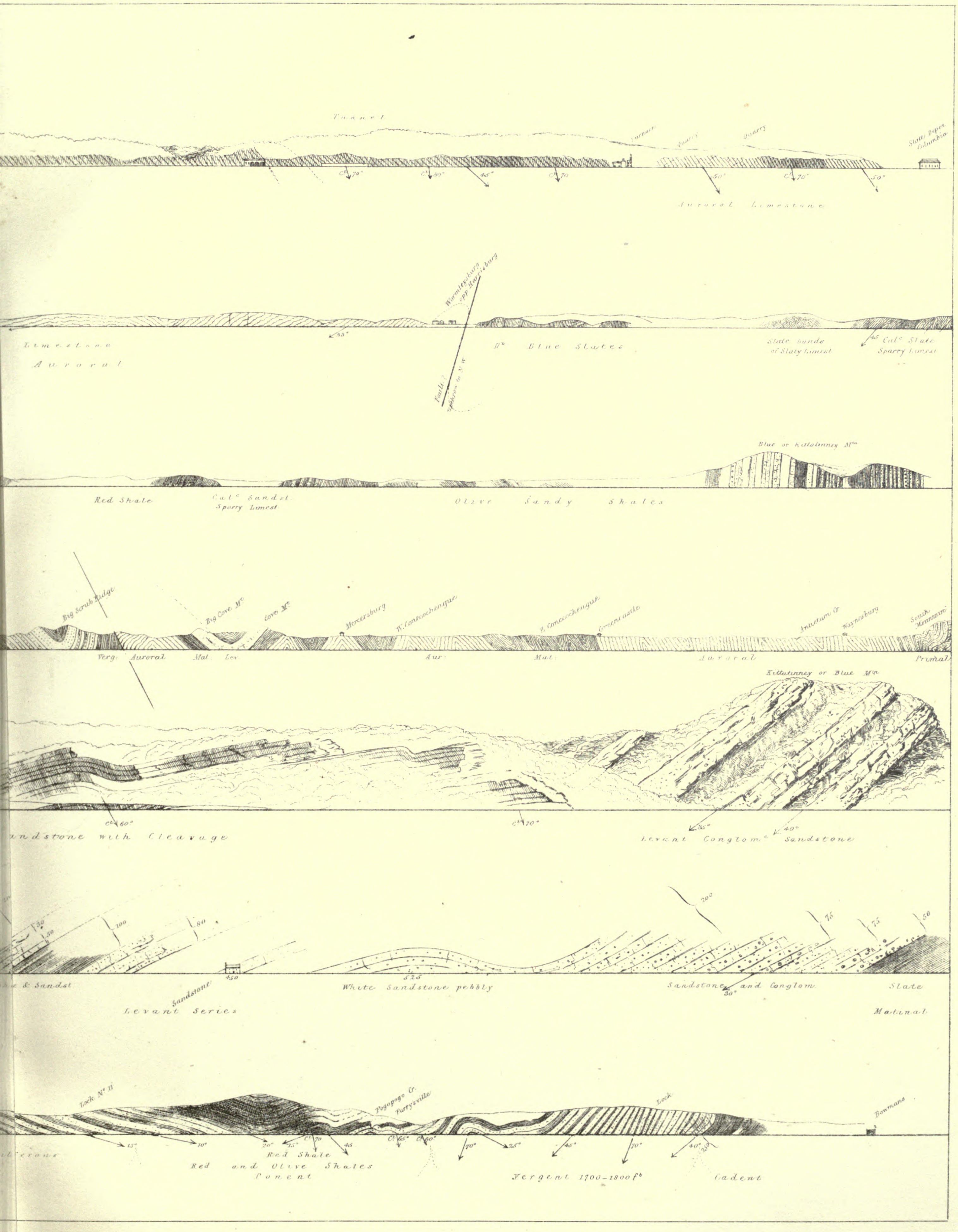
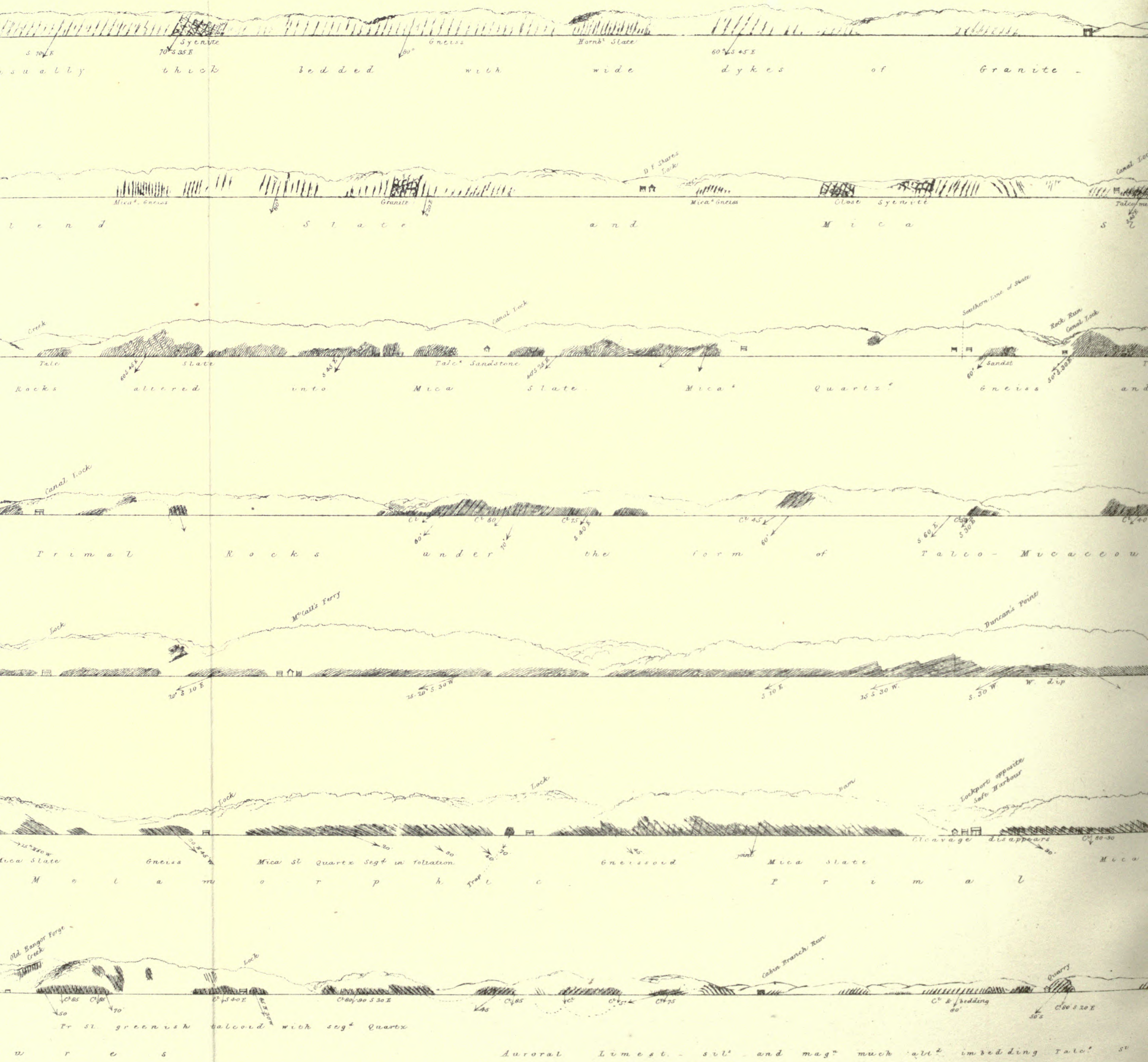

Section on Susquehanna River from Chiques Rock to Columbia — looking N. E.
Chiques Rock
Henry Clay Furnace
Primal Sandstone
Primal Upper Slate
Section across Kittatinny Valley, W. side of Susquehanna River
New Market
Yellow Breeches Cr.
New Cumberland
Thin bedded blue and white Limestone
Light-blu
Section across Kittatinny Valley, West bank of Susquehanna River — looking S. W. 1 inch = ¼ mile
Conedoguinet Cr.
Fairview
Dusky blue Slates
Cal.^c Shale
Olive Sandy
Matinal
Section from Alleghany M.^t West of Bedford to the South M.^ts near the Maryland Line
Alleghany M.^t
Juniata R.
Wills Creek M.^t
Bedford
Tussey's M.^t
Rays hill
Brush Cr. Valley
Sideling hill
Section at the Delaware Water Gap 1 inch = 800 f.^t
Post M. Shale 150
Cale Shale 50
Meridl
Road
Diluvial Flats
Cherry Cr.
Dutotsburg
Brodhead's Hotel
Pre Merid.
Surgent Red Shale
Surgent Red and variegated Sandy Slates and Red Argilla
Section at the Lehigh Water Gap 1 inch = 300 f.^t
Variegated Sh.
Aquanshicola
Hotel
Red Sandst. and Red Shale alternating
Surgent Series
Newer Calc.^t Sh.
Ore Sandst.
Red Iron Sandst.
White & Red Sandst.
Olive Shales
Section down Lehigh River through Weissport to Bowman's 1 inch = 1200 f.^t
Lock of Canal
Boat House
Lock
Lock opposite Weissport
Lock
Lock 10
Olive Shales and Black Slates Fossils
Flaggy grey argil.^s Sandst. and blue Shal
Cadent
Vergent

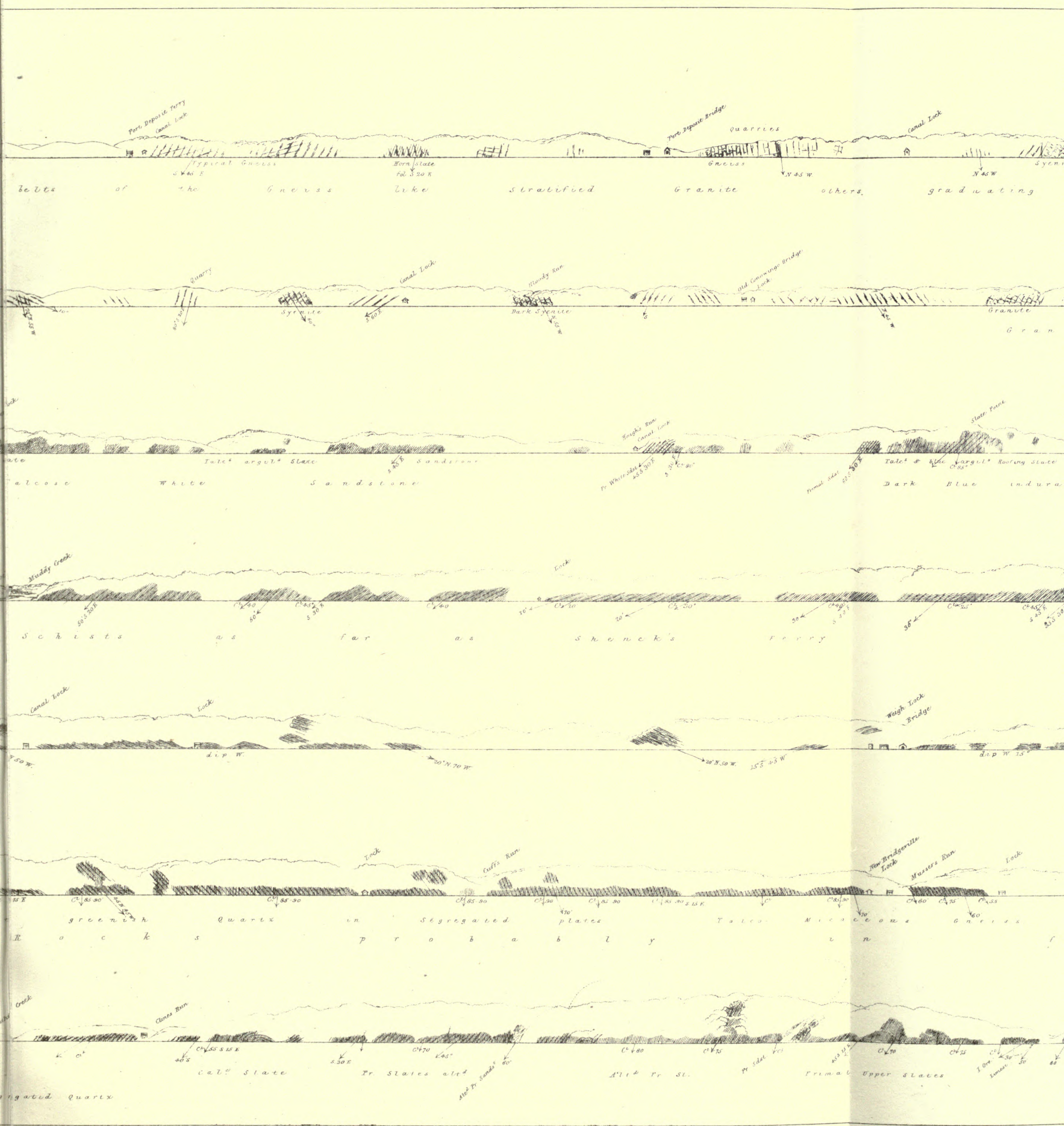


Tunnel
Quarry
Quarry
Auroral Limestone
Limestone
Auroral
Blue Slates
Slate bands of Slaty Limest
Calc Slate Sparry Limest
Blue or Kittatinney Mtn
Red Shale
Calc Sandst. Sparry Limest
Olive Sandy Shales
Big Scrub Ridge
Big Cove Mt
Cove Mt
Mercersburg
Greencastle
Waynesburg
Auroral
Aur:
Mat:
Auroral
Primal
Kittatinney or Blue Mtn
ndstone with Cleavage
Levant Conglom. Sandstone
White Sandstone pebbly
Sandstone and Conglom
Slate
Levant Series
Matinal
Lock
Bowmans
Red Shale
Red and Olive Shales
Ponent
Vergent 1700-1800 ft
Cadent

de Grace along S. W. shore of Susquehanna River to Wrightsville. _ looking S. W. 1 inch = 1000 ft

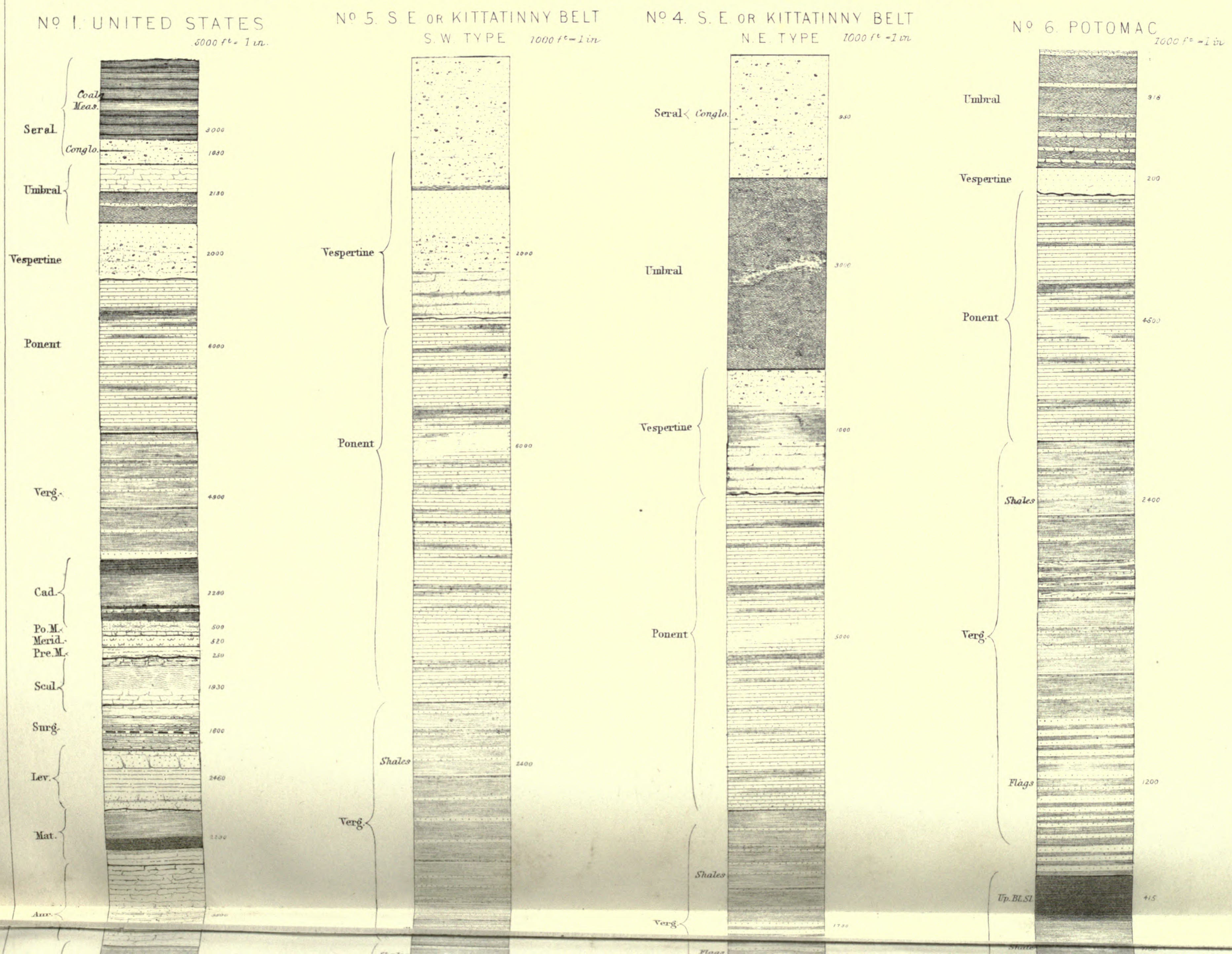


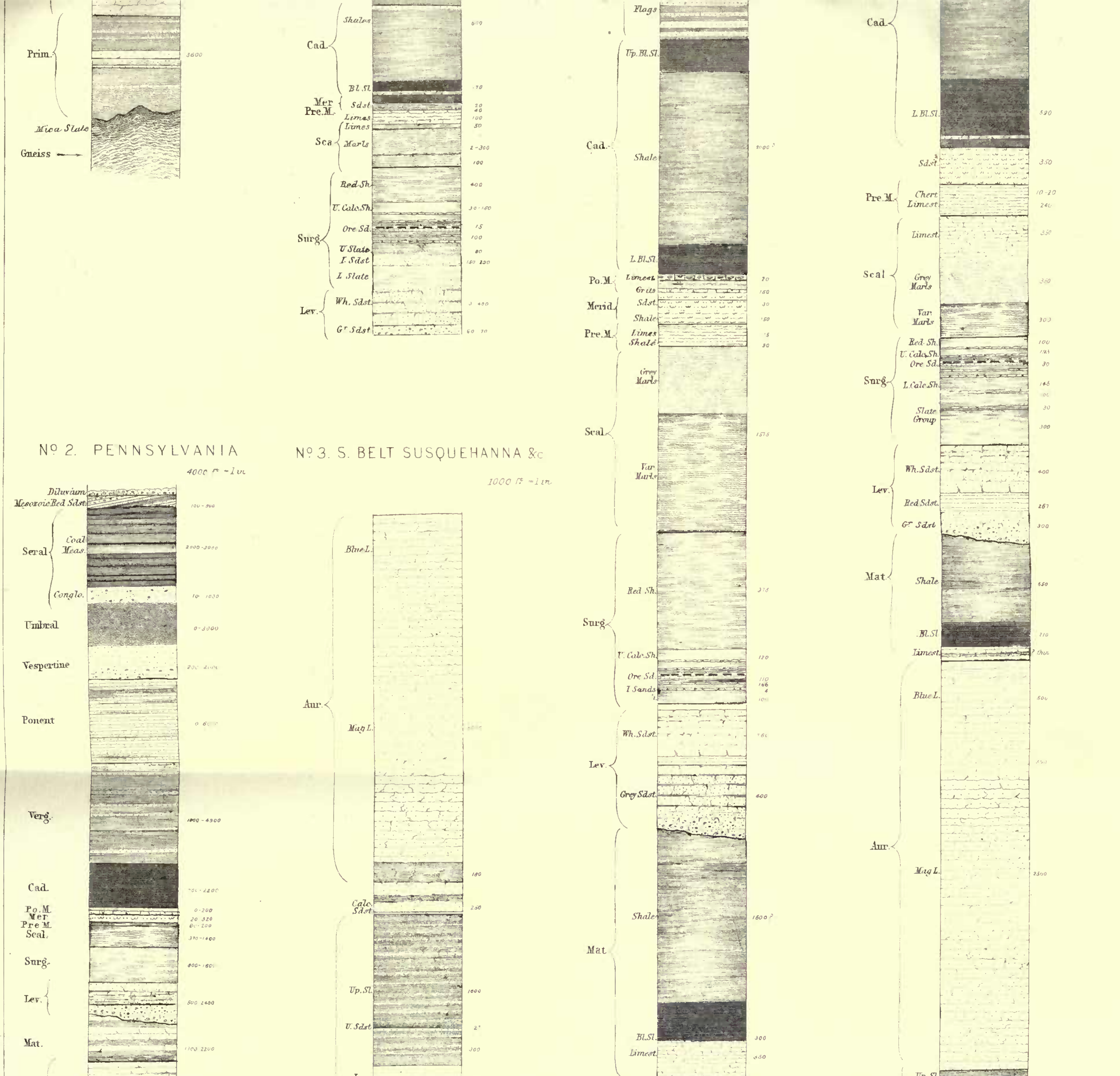
Court of the United States, in and for the Eastern District of Pennsylvania.



Port Deposit Ferry
Canal Lock
Port Deposit Bridge
Quarries
Canal Lock
Typical Gneiss
Horn Slate
Gneiss
N 45 W
N 45 W
belts of the Gneiss like Stratified Granite others graduating
Quarry
Canal Lock
Bloody Run
Old Conemingo Bridge
Lock
Syenite
Dark Syenite
Granite
Gran
Hughs Run
Canal Lock
Slate Point
Talc^d argil^s Slate
Sandstone
Talc^s & blue argil^s Roofing Slate
Talcose White Sandstone
Dark Blue indura
Muddy Creek
Lock
Schists as far as Shenck's Ferry
Canal Lock
Lock
Weigh Lock
Bridge
dip W.
20° N. 70 W.
20° N. 50 W.
dip W 15°
Lock
Cuff's Run
New Bridgeville Lock
Mussers Run
Lock
greenish Quartz in Segregated plates Talco Micaceous Gneiss
Rocks probably in
Creek
Climes Run
Cal^d Slate
Pr. Slates alt^d
Alt^d Pr. Sand^s
Alt^d Pr. St.
Pr Sdst
Primal Upper Slates
I Ore
ngated Quartz

COLUMNAR SECTIONS OF THE PALÆOZOIC STRATA

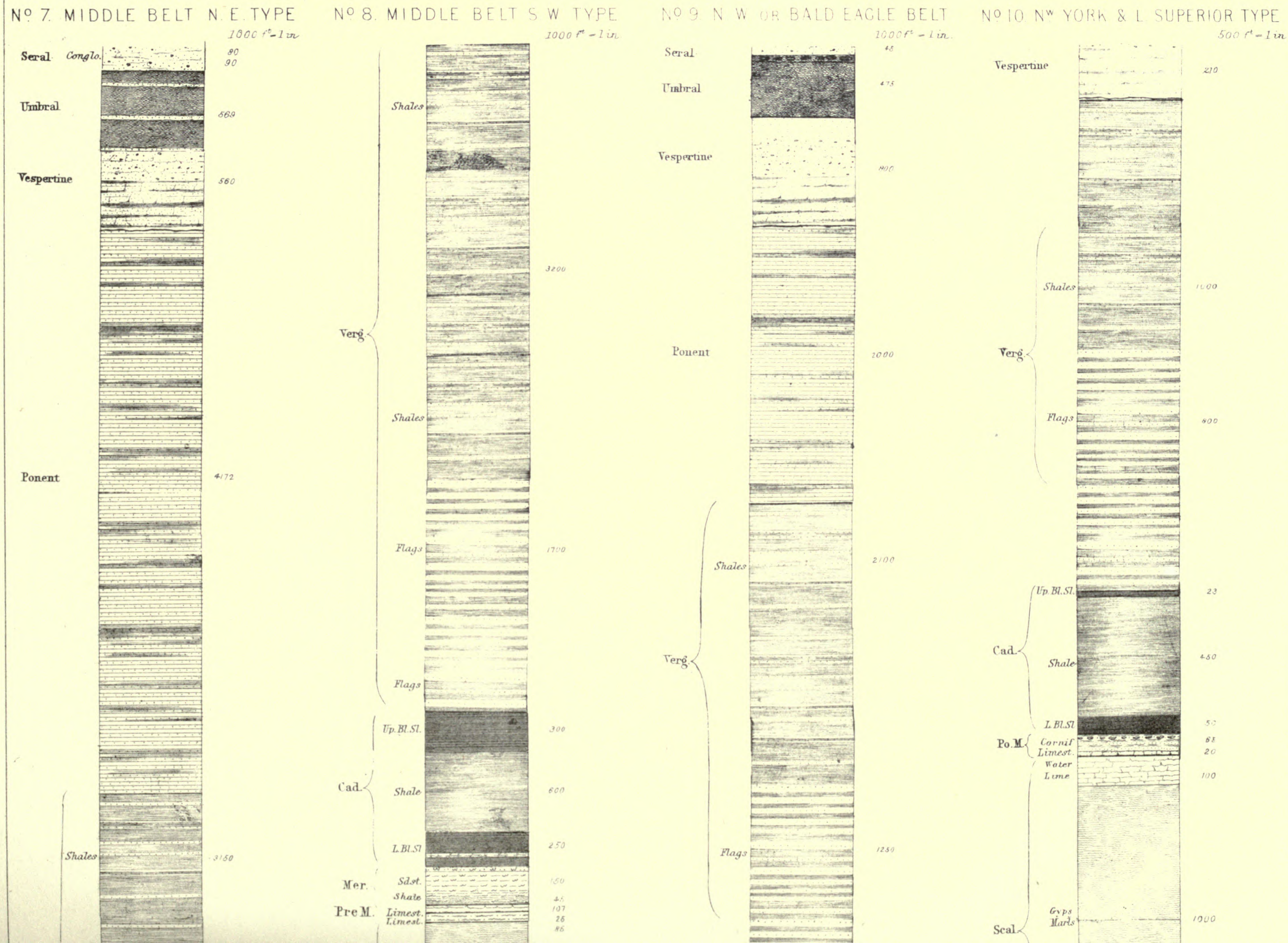


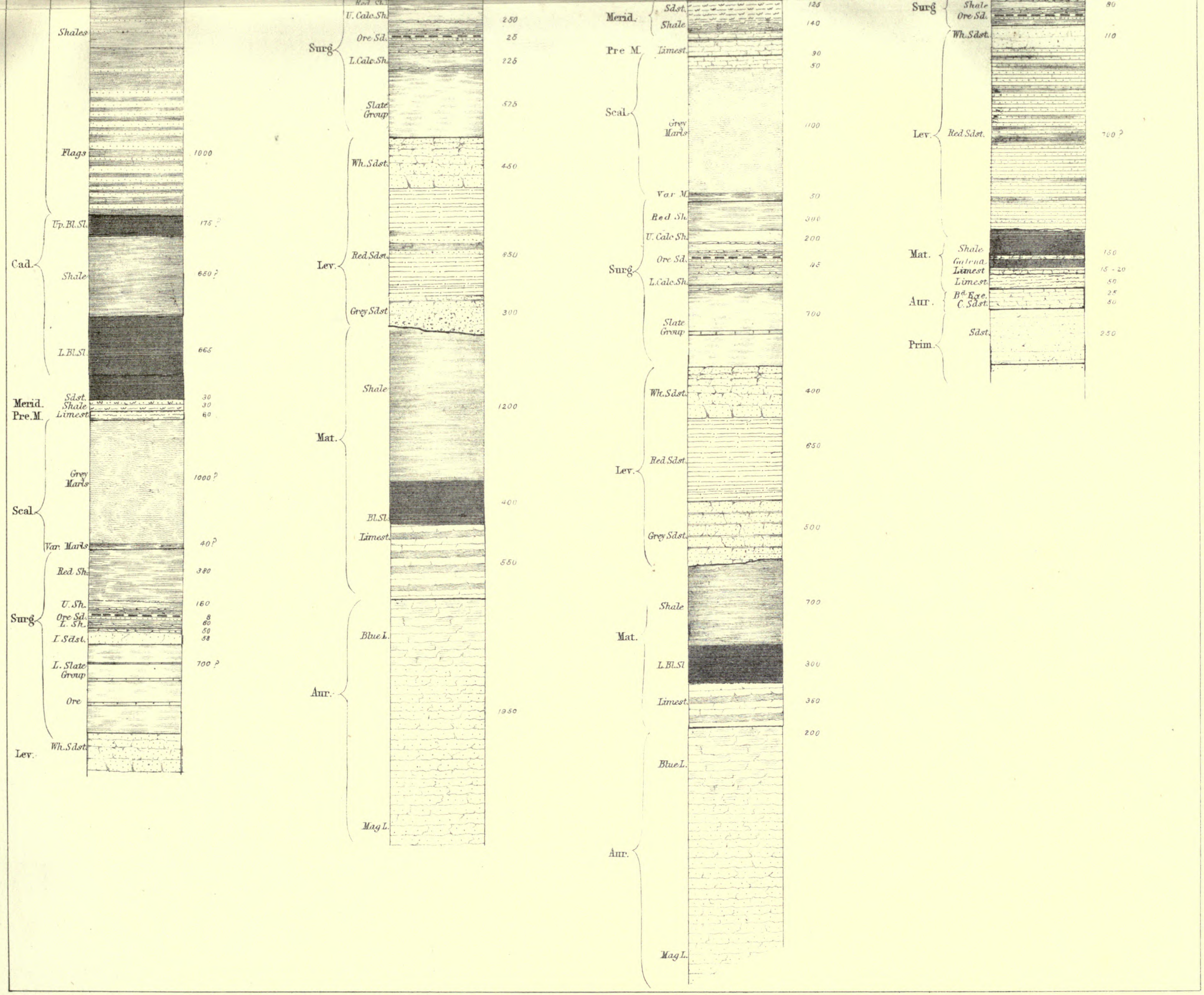


Prim.
3600
Mica Slate
Gneiss
Cad.
Shales
600
Bl. Sl.
Mer
Pre.M.
Sdst
Limes
Limes
Sca.
Marls
Red Sh.
U. Calc.Sh.
Ore Sd.
U Slate
I. Sdst
L Slate
Surg.
Lev.
Wh. Sdst.
Gr Sdst
N° 2. PENNSYLVANIA
4000 Ft = 1 in.
Diluvium
Mesozoic Red Sdst.
Seral
Coal Meas.
Conglo.
Umbral
Vesperline
Ponent
Verg.
Cad.
Po.M.
Mer
Pre M.
Scal.
Surg.
Lev.
Mat.
N° 3. S. BELT SUSQUEHANNA &c
1000 Ft = 1 in.
Blue L.
Aur.
Mag L.
Calc. Sdst.
Up. Sl.
U. Sdst.
Low.
Flags
Up. Bl. Sl.
Cad.
Shale
L. Bl. Sl.
Po. M.
Limest.
Grits
Merid.
Sdst.
Shale
Pre. M.
Limes
Shale
Grey Marls
Scal.
Var. Marls
Red Sh.
Surg.
U. Calc. Sh.
Ore Sd.
I Sands
Wh. Sdst.
Lev.
Grey Sdst.
Shale
Mat.
Bl. Sl.
Limest.
Cad.
L. Bl. Sl.
Sdst.
Pre. M.
Chert Limest.
Limest.
Scal.
Grey Marls
Var. Marls
Red Sh.
U. Calc. Sh.
Ore Sd.
Surg.
L. Calc. Sh.
Slate Group
Wh. Sdst.
Lev.
Red Sdst.
Gr Sdst.
Mat.
Shale
Bl. Sl.
Limest.
Blue L.
Aur.
Mag L.
Up. Sl.

COLUMNAR SECTIONS OF THE PALÆOZOIC STRATA

COLUMNAR SECTIONS OF THE PALÆOZOIC STRATA





Shales
Flags 1000
Up.Bl.Sl. 175?
Cad.
Shale 650?
L.Bl.Sl. 665
Merid. Sdst. 30
Pre.M. Shale 30
Limest. 60
Grey Marls 1000?
Scal.
Var. Marls 40?
Red Sh. 380
U. Sh. 160
Surg. Ore Sd. 8
L. Sh. 60
L. Sdst. 50 58
L. Slate Group 700?
Ore
Lev. Wh. Sdst.
U. Calc. Sh. 250
Surg. Ore Sd. 25
L. Calc. Sh. 225
Slate Group 575
Wh. Sdst. 450
Lev. Red Sdst. 850
Grey Sdst. 300
Shale 1200
Mat.
Bl. Sl. 400
Limest. 550
Blue L. 1950
Aur.
Mag L.
Merid. Sdst. 125
Shale 140
Pre M. Limest. 90 50
Scal. Grey Marls 1100
Var. M. 50
Red Sh. 300
U. Calc. Sh. 200
Surg. Ore Sd. 25
L. Calc. Sh.
Slate Group 700
Wh. Sdst. 400
Lev. Red Sdst. 650
Grey Sdst. 500
Shale 700
Mat. L. Bl. Sl. 300
Limest. 360
Blue L. 200
Aur.
Mag L.
Surg. Shale 80
Ore Sd.
Wh. Sdst. 110
Lev. Red Sdst. 700?
Mat. Shale 150
Galena
Limest 15-20
Limest. 50
Aur. Bd Ege. 25
C. Sdst. 50
Prim. Sdst. 250

815

Storage